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A

REPORT

OF

MICROSCOPICAL & PHYSIOLOGICAL RESEARCHES

INTO THE

NATURE OF THE AGENT OR AGENTS PRODUCING CHOLERA.

BY

T. R. LEWIS, M.B., AND D. D. CUNNINGHAM, M.B.,
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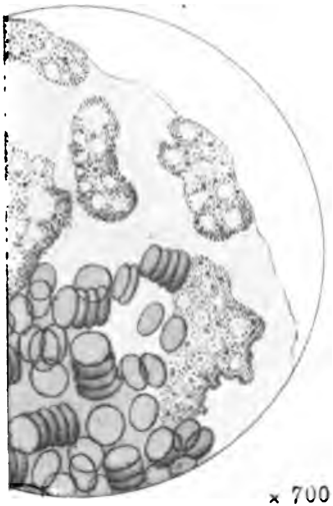

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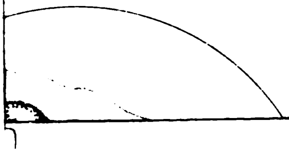

MICROSCOPICAL & PHYSIOLOGICAL RESEARCHES

INTO THE

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T. R. LEWIS, M.B., AND D. D. CUNNINGHAM, M.B.

INTRODUCTION.

In the Instructions issued by the Army Sanitary Commission for the conduct of this enquiry, particular stress is laid on the importance of accepting no statement bearing on the question of the mode of origin and diffusion of cholera as proven, no matter how distinguished the authority on which it may have been made, until an opportunity occurred for verifying it for ourselves. It has been our endeavour to adhere strictly to this injunction, and we have therefore gone over ground on which, under other circumstances, might have been considered unnecessary for us to enter. This, however, we do not by any means regret, as the experience gained by such a training has more than compensated for the time and labour expended on it. It has obliged us to be more on our guard than we might otherwise have been, especially in connection with observations that have been authoritatively put forth regarding some low forms of life, and of the interpretations which have been made concerning the effects of various experiments on lower animals.

We do not for a moment expect, nor do we wish that our own observations should be accepted in a different spirit;

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* Being one of the Appendices to the eighth Annual Report of the Sanitary Commissioner with the Government of India.

on the contrary, we should be glad to see them practically tested by those who have the opportunity of doing so. The observations here recorded are submitted as facts; in no instance has an observation been included which had not been witnessed by both of us; any observation one may have made, which had not been verified by the other, has been allowed to stand over. The interpretation which we have ventured to put on some of these observations may of course be erroneous, but the facts have, to the best of our ability, been accurately recorded, so that no one need be led astray by any faulty inferences of ours.

We have, as far as possible, carefully avoided the introduction into the text of any descriptive terms involving the acceptance of a theory, although it would have been in some cases very convenient to have adopted some of the ingeniously coined words lately admitted into our medical vocabularies. To the authors of some of the terms which we have employed we are particularly indebted, and we wish specially to acknowledge the aid we have received from a study of the writings of Professors Beale, Burdon Sanderson and Bastian.

Our report has been divided into three parts; the first containing a description of the microscopical appearances of the blood in cholera; the second giving an account of a series of experiments on the action of solutions of organic matter from various sources and in various stages of decomposition on living animals; and the third, on the effect of section of certain nerves.

PART I.

MICROSCOPIC EXAMINATIONS OF HUMAN BLOOD.

A.—Results of microscopic examinations of the blood in cholera, together with a description of the methods adopted.

The importance of making *continuous* examinations of the blood.

Although results of careful examinations of the chemical characters of the blood in cholera have been frequently made, investigation of the microscopic characters presented by it, and more especially of the changes and developments occurring in it when removed from the body, has been comparatively neglected. As the subject is one of very great importance, and is daily becoming more so on account of the ideas now prevalent regarding the disease, it has been carefully investigated, and the general results, attained from numerous series of experiments, are briefly stated below. Any system of examination not allowing of prolonged and continuous study of individual specimens of blood, as well as of exact observation of their characters when first removed from the body, is necessarily unfitted to furnish trustworthy information, and before entering on the subject, it became necessary to devise means suited to the attainment of both these ends.

Methods adopted for the immediate examinations of blood.

The requirements of the case appeared to be sufficiently met in the following way. For purposes of immediate examination, specimens of blood were placed under thin covering-glasses, individual specimens being prepared without any re-agent, mounted in acetate of potash after exposure to the vapour of a two per cent. solution of osmic acid, or mounted in acetate of potash or acetate of soda without previous exposure to the osmic fumes.

The advantages of employing wax-cells for continuous examinations.

For continuous observations on the changes taking place in the blood after its removal from the body, wax-cells were employed. A small drop of blood having been received on the centre of a carefully cleaned covering-glass, the latter was pressed down on the wax-cell and hermetically sealed. The cell was deep enough to prevent the blood coming in contact with the slide, and therefore allowed of its free exposure to the included air.

The air contained in such cells sufficient for developmental purposes.

This form of wax-cell is a modification of that employed by Stricker in similar investigations on the blood, and is identical with that described by Berkeley as specially adapted for observations on the development of fungi. The great advantage of the method is, that, when once the specimens have been carefully sealed, large numbers of cells may be retained in perfect condition for examination without calling for the employment of the moist chamber and its inherent fallacies, arising from the constant possibility of the introduction of extraneous elements into the material under observation. The effect of any such cells in facilitating observation may be judged of by the fact that by their means specimens of blood have been kept in a condition for continuous observation for nearly three months at a time. That sufficient air is included in them to allow of developments taking place in the isolated droplet of blood may be demonstrated by the results of certain observations to be hereafter referred to.

The samples of blood where and how obtained.

The specimens of blood during life were generally derived from the point of one of the fingers of the patient (which had been carefully washed with spirit or clean water and thoroughly dried) by pricking it with a needle. Those after death were usually obtained from one of the chambers of the heart.

Having briefly explained the methods which have been adopted in carrying out these observations, we now proceed to a description of the results obtained under these conditions.

1.—*Appearances presented by the blood, when treated with osmic acid and acetate of potash.*

Osmic acid preparations of cholera blood.

The absence of bacteria in cholera-blood obtained during life, but

The red corpuscles appeared unaltered in most cases; in one or two, they conveyed an undefined impression of softness. Few leucocytes were present as a rule, but in one specimen they were present in some numbers, along with other cells of considerably larger size and extremely delicate in outline, and structure. Not the faintest trace of bacteria was detected in any instance, although they were carefully searched for under powers ranging from the $\frac{1}{4}$ to the $\frac{1}{12}$ *à immersion.**

numerous particles of bioplasm are present.

There were, however, as a rule, numerous specimens of minute irregularly rounded bodies giving a refraction like that of the leucocytes, and varying considerably both in size and form. They occurred sometimes in little patches or heaps, and in other cases, were irregularly scattered over the field. No structure could be detected in them, and they appeared to be mere fragments of bioplasm (See Plate; Fig. 1).

All these bodies, red cells, leucocytes and minute bioplasts, were spread out in a medium precisely similar to that observed in normal blood, when prepared with osmic acid, almost homogeneous, in some places very finely molecular, and marked by faint delicate curved lines.

Preparations of blood obtained after death and treated in the same way presented precisely the same features. The only characteristic distinguishing them from the most healthy blood, was the presence of numerous bioplastic fragments described above, and even this did not appear to be constant. Any discussion of the probable nature of these bodies will be better deferred until a description of the changes occurring in the blood have been described.

Appearance of the blood with and without the addition of re-agents.

Specimens of blood to which no re-agent had been added, and others treated with acetate of potash or acetate of soda, only differed from those treated with osmic acid in showing the minute bioplastic bodies less constantly and distinctly.

2.—*Appearances presented by specimens of blood in wax-cells.*

Description of the blood in wax-cells when perfectly recent.

When examined immediately after preparation, these, as a rule, presented nothing noteworthy or in any way characteristic. In one or two instances the serum was stained with the colouring matter of the red corpuscles, but in general it was perfectly clear, free of staining and molecules or particles. The serum at first appeared as a very narrow ring around the corpuscles, but, as a rule, this rapidly widened as the mass of the latter contracted, and ultimately it formed a wide clear area of fluid around the clot. The number of white corpuscles at first visible was small and not noteworthy, but with the formation of the ring of clear serum a series of most remarkable phenomena gradually presented itself. Normal sized white corpuscles began to migrate into the fluid, but in addition to these, and in far greater numbers and activity, were much larger and more delicate bioplastic bodies; cells they were not, for they had not at this time the faintest differentiation of wall, contents, or nucleus. They were simply masses of fluid bioplasm—bioplasm so fluid and diluted as in many instances to be almost, if not entirely, indistinguishable by refraction from the surrounding medium. Again and again, has a patch of scattered granules been noted moving in unison across the field, and only after prolonged examination and most careful management of the light has it appeared that the individual granules were really included in a portion of bioplasm and were moved by its movements only. Gradually the consistence of these large bioplastic masses appears to increase, and they, as it were, grow into sight (Fig. 2). Their movements are extremely constant and free, no mere alterations of form, but free progression, along with such movements. The alterations in form vary extremely, sometimes consisting of the emission of rounded and lobulated protrusions, and at others of the running out of elongated slender extensions and threads.

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* Latterly a $\frac{1}{25}$ objective by Powell and Lealand was employed, but we confess that, notwithstanding the most careful corrections being made for thickness of covering-glass, &c., we found it practically inferior to the $\frac{1}{8}$ and $\frac{1}{12}$ *à immersion* of Ross. We are, however, in daily expectation of a $\frac{1}{16}$ objective by the former distinguished makers, a glass having the reputation of being the most perfect hitherto constructed.

And the changes which gradually take place in it.

Coincidently with the appearance of these bodies in the marginal serum, others of a similar nature may be observed in the serous spaces in the clot, and at this time also, in some cases, an abundance of small refractive bioplasts may be detected in the same localities. These small bioplastic bodies have seldom been seen to move or alter form, and, save slight increase in size, have not been observed to undergo any change, and seem shortly to disappear. In a few instances also the interspaces of the clot are occupied by very delicate branched fibrillæ, but this is by no means a constant or characteristic phenomenon.

The serous spaces in the clot.

The question here arises, are these large masses of bioplasm the results of very rapid new development, or are they present in the blood from the beginning, but so fluid and so closely approaching the surrounding medium

Concerning the nature of the masses of plasma which have crawled out of the clot.

in density as to be indistinguishable until rendered somewhat firmer by changes occurring in them, induced by altered temperature of the medium or slight chemical changes in it, or unless they come to contain granular matter? At the close of an hour after the blood has been drawn, they are to be found in abundance crawling free in the serum and issuing from the edges of the clot. It is possible that the irregularly rounded particles in the osmic preparations may be due to the breaking up of these bodies, and the subsequent condensation of the substance of the bioplastic fragments resulting from the rupture. For a short time the ring of serum, and the serum above the clot, is full of these large irregular masses of bioplasm, moving freely in all directions. Soon, however, they begin to sub-divide and break up into a second generation of bioplasts (Fig. 3). The process of division can be seen most distinctly, sometimes occurring rapidly and, so to speak, decisively; whilst at others, after the two secondary bodies are widely separated, and only connected by a very slender, barely visible thread, one is retracted and, as it were, absorbed into the mass of the other, to be succeeded by one or more similar protrusions, ere division fairly takes place; the serum now swarms with multitudes of bioplasts of smaller size than those originally present, but resembling the previous generation in their delicacy of outline and great activity. The bioplasts may frequently be observed at the edge of the rim of serum crawling along it, and, as it were, moulded to the curve of the marginal fluid (Fig. 3).

Segmentation of the bioplasts.

The period of extreme activity varies considerably, but, as a rule, at the close of twenty-four hours from the commencement of the observation, only a few remain freely motile, and the majority have considerably increased in size (Fig. 4). Towards the close of the freely moving, amœboid period, the density and refractiveness of the bioplasts increase, and there is an increase in the number and distinctness of the granules contained in their substance. Many, too, in place of remaining uniformly granular, begin to show a tendency to the formation of one or more nuclear spaces or vacuoles (Fig. 4), which appear as bright spots surrounded by more or less defined circles of granules. As the movements of the bioplasts diminish, this vacuolation increases in distinctness, and

Duration of activity of bioplasts.

Formation of vacuoles.

is very well marked when they have fairly ceased, which they do very gradually; changes in form persisting for some time after the cessation of free locomotion. As the movements cease, the majority of the cells also assume a more or less rounded form, a few only becoming fixed with irregular or lobed outlines, and contemporaneously they tend to accumulate in heaps and masses of varying extent (Fig. 4).

Aggregations of pus-like cells.

The preparation in this stage shows a multitude of irregular masses, composed of bodies which vary considerably in size, and which in refractiveness and general aspect closely resemble pus-cells in which the vital movements have ceased. The vacuoles are now very distinct and well defined, and the entire body has a denser, 'plumper' appearance than it ever had before.

Further changes in the bioplasts.

May break down into monad-like colonies; or

Whilst these phenomena have been taking place the serum remains quite clear and free of bacteria or monads, and the only change which occasionally occurs in it is a certain amount of staining, due to the escape of colouring matter from the corpuscles as the clot begins to soften. The preparation having reached this stage may remain unchanged for weeks, the serum continuing perfectly fluid and clear throughout, but in the majority of cases, the bioplasts pass on to further changes. The exact nature of these changes varies greatly in individual preparations and in the individual bioplasts of the same preparation. The bioplasts may gradually break up and disintegrate, filling the serum with molecular flakes, which for some time show indications of the outlines of the individual masses with more or less distinctness, but ultimately become uniform. Such flakes might very readily be described as flakes of monads, and be supposed to arise by aggregation, had the processes by which they are formed not been followed out. This may be regarded as the simplest method of termination of the bioplasts, but there are others which are more complex, and which, inasmuch as they give rise to very different appearances in individual specimens of blood, must be clearly distinguished and described. In many instances there appears to be a certain condensation of substance around the vacuole or vacuoles so as to leave a more fluid ring between this condensed portion and the outer margin of the bioplast, which at the same time assumes more or less clearly the appearance of a very delicate cell wall (Fig. 5). The granules contained within this fluid ring now take on an active swarming motion exactly resembling that observed in some common amœbæ occurring in specimens of water, and in the cells of many of the lower algæ. The movement persists for some time, and then, either ceases leaving the bioplast apparently in the same condition in which it was previously, or the outer wall of the cell ruptures, and the swarming granules escape (Fig. 5). Once beyond the parent body and free in the fluid, they immediately become motionless, and have never been observed to move again. What the nature of these particles is, and to what their activity is due, remains uncertain, but they can, at all events, hardly be regarded as bacterial germs, seeing that their period of activity is confined to the period in which they are still contained within the parent bioplast.

become "nucleated cells" with active molecules between the "nucleus" and a very delicate outer wall.

The result of the escape of the granules is to convert the formerly uniform, granular, vacuolated bioplast into a body, consisting of a delicate cell-wall and a nuclear mass which does not nearly equal the cell-wall in circumference. This mass may remain more or less centrally situated, or, as more frequently occurs, it may pass to one or other side, and may then escape partially or even entirely from the cell-wall. The appearances naturally vary with the nature of the process which has taken place. In those cases in which the nuclear mass remains central, the entire body appears as a bright space bounded by a dark line, and containing a central molecular mass, while in those in which it goes to the side or escapes through the cell-wall, the bright space is left equally sharply defined from the surrounding fluid, but is either crescentic or quite empty and circular. Probably the most common appearance is that of a broad, bright, sharply defined crescent, the concavity being formed by the portion of the nuclear mass which is still included within the cell-wall, while the rest of it protrudes as a rounded mass exterior to it (Fig. 5.), but empty spaces with free masses of granules condensed or scattered in various degrees are also abundantly present at this time. This escape or expulsion of the contents of the cell may take place without any previous formation of a nuclear mass and motile granules, but the result in any case is ultimately the same, and a series of bright, sharply defined, more or less empty, hyaline capsules remains.

Origin of the "hyaline-cells" with central or lateral "nucleus."

This appearance varies with their situation: when free in the fluid they come out as pure white, flat spaces with fine dark outlines; whilst, when situated among the corpuscles, they are usually delicately shaded. The persistence of these capsules is wonderful, considering their extreme delicacy; and the surrounding fluid does not appear to enter them, or to cause them to collapse, although in some cases there appears to be open fissures in them. The nuclear masses gradually disintegrate after their exit, and are diffused through the fluid as flakes of molecular matter (Fig. 5).

Persistence of the "hyaline-cells."

Peculiar appearances are induced during the progress of the above changes in those cases in which masses of cells have been embedded in the interspaces of the clot, and in which the whole preparation has, as is sometimes the case, passed into a syrupy condition. The outer walls of the cells appear to adhere to one another and to the margins of the interspaces, and the contents shrinking away and condensing appear as small circular masses in the centre of empty irregular vacuoles in the clot.

Changes in the interspaces in the clot.

Subsequently to the escape of the contents of the cells, there is in many cases an abundant development of irregularly oval and rounded particles of various sizes throughout the preparation. They are of various forms, globular, irregularly lobed, and either scattered or arranged in pairs, trios or series (Fig. 6). Many of the series are very complex and much ramified, whilst others consist of linear series, each member of which is smaller than its predecessor. The nature of these bodies remains quite uncertain. Beyond a certain increase in size they have not been observed to undergo any further development, and in many cases they are probably of an oily nature. When of such a nature, they are from the first brightly refractive and perfectly structureless, and are ultimately, at the close of one or two months from the commencement of observation, resolved into oily flakes and strings, the latter of which might easily be mistaken for vibriones or fungal threads, more especially when they begin to break up into rows of separate oil globules.

Particles of an oily nature appear,

In others, however, this does not appear to be the case, as they may in these instances be observed to become finely molecular, so that the preparation is ultimately crowded with

together with more persistent molecular matter.

minute molecular patches of various forms (Fig. 6). It is possible that the latter bodies may be the escaped, so-called 'vacuoles' of the bioplasts. These are always surrounded with a portion of more or less condensed material, which would be likely to persist after the solution of the surrounding softer material.

'Milky spots' in blood-preparations.

As is frequently the case in preparations of blood kept under continuous observation in the same way as the above, milky spots, due to the appearance of small homogeneous circular bodies, may be observed in some numbers in the fluid, but they have not been seen to undergo any further development, and, as a rule, do not persist long.

After the appearance of the particles above described, the only further change noted has been a gradual disintegration of all the elements of the preparation; and, although the latter have frequently been kept for weeks under observation, no further development has taken place, and with very few and accidental exceptions, there has been no appearance of recognizable fungal, or bacterial elements in them.

Remarks.

It now remains to make a few remarks on the principal points of interest in connection with these observations. The conveniences afforded by a tropical climate for any such series of observations as these are very great, as the temperature as a rule is sufficiently high to secure that the activity of the bioplasts contained in the blood is not too rapidly checked. During a period of frequent observation in the course of the past season the thermometer ranged from a maximum of 98·2° F. to a minimum of 76·3° F.

An objection to the use of immersion lenses is the lowering of temperature which they cause.

It is not devoid of interest to remark that the use of immersion objectives involves a disadvantageous depression of temperature, due to evaporation of the film of water, which is placed between the lens and the covering-glass. The prolonged use of such a lens has frequently appeared in this way to check the activity of the bioplasts in the blood.

Total absence of bacteria in the blood in every stage of cholera.

One of the most important points determined by these observations is the fact, that the blood in cholera is, as an almost invariable rule, free from bacteria, either actual or potential. This is the case as well shortly after death as during life, and holds in regard to every stage of the disease. In one or two cases, a slight development of distinct bacteria has occurred during the course of observation, but this is no more than may occur in the most healthy specimens of blood, and the idea that bacteria are normally present in the blood in cholera may be finally dismissed. It is not improbable that certain of the appearances observed in series of observations, such as those described above, may afford a clue to the origin of such an idea. At an early stage when the bioplasts are of great fluidity and tenuity, monad-like granules, contained in and moving with them, may be supposed to be free and endowed with independent motion, but this will be found, on prolonged observation, not to be the case, and as the density of the bioplasts increases the true relations of the granules will appear. At a much later stage, namely, at that of escape of the contents of the cells, patches of molecular matter and scattered granules may result; and finally, when general disintegration of the bioplasts occurs, large sheets and masses of evenly molecular matter may occupy much of the preparation, but these granules, micrococcoid patches and molecular flakes, are no new developments, but are clearly traceable to mere disintegrative changes in bodies previously present.

The molecular matter so produced, be it scattered or aggregated, undergoes no further development, and shows no motion or any other indication of vitality. The term bacteria is often very vaguely and loosely employed, but it is under no pretext, applicable to mere dead particles due to simple disintegration.

No fungal elements could be seen or subsequently developed in the blood of patients in cholera.

As regards bacteria, so it is in regard to the presence of fungal elements as a normal and constant characteristic of the blood in cholera. There is absolutely nothing in favor of any such view; there is absolutely no evidence of the existence of fungal elements in the blood whilst in the body, and only very rare and clearly accidental development of such bodies after its removal from it. These questions, however, will be more fully referred to in a succeeding section (page 18).

The marked resemblance between the bioplasts in the blood and the bioplasts in choleraic dejections.

Possibly the most important result to be derived from observations on the blood in cholera, conducted in the manner described above, is the explanation which they are capable of affording of the nature of the bioplastic bodies and cells so abundant in, and so characteristic of, evacuations passed during the course of the disease. We have previously pointed out that such evacuations frequently contain evidences of the escape of blood into the intestines, either by the presence of red corpuscles in greater or less abundance, and occasionally included within the characteristic cells of the discharges, or by that of a more or less pronounced pinkish and sanguineous tinge of the fluids, with the subsequent appearance of blood crystals in them. Now if, as observation has proved, the bioplasts contained in the blood are capable of such activity and multiplication when removed from the body, and with quite abnormal surroundings, it is surely fair to allow them an equal, if not superior, capacity when exuded on the interior surface of the intestines.

Such bioplasts, in passing through the various changes described above, will come to present every modification of appearance and characters presented by those found in the discharges. In their earlier stages they will correspond with the freely motile amœbæ of the evacuations; when rather older they lose their freedom of motion and show mere feeble changes of form, ultimately becoming motionless and pus-like or rather exudation-like cells, such as are observed in the flakes of lymph in peritonitic and similar effusions, and such cells we know to form the great bulk of those present in perfectly recent choleraic dejections.

Whilst in this condition it has been already mentioned that they frequently show one or more distinct nuclear vacuoles in their interior, and they are then identical in aspect with the large mother-cells containing bioplast-masses, previously described in connection with the subject of the evacuations.

The 'hyaline-cells' in the blood and in the discharges identical in appearance.

There is one class of bodies in the evacuations, the nature of which has hitherto been peculiarly puzzling and obscure, namely, that of flattened, whitish or pale-yellowish hyaline cells showing no evident structure or contents, but the observations on the changes occurring in the bioplasts of the blood explain the nature of these also, for the empty capsules persisting after the escape of the molecular contents of the pus-like cells, are exactly similar to the hyaline bodies of the evacuations, and unless the actual steps in their formation had been followed, their nature would have been as obscure as that of the latter cells has till now remained. Hyaline vesicles, somewhat resembling these are, more or less, generally found in all intestinal discharges, and are probably the result of endosmotic processes acting on the epithelial cells, as was long ago pointed out by Heidenhain and Brücke in connection with appearances observed in healthy epithelium; they may occasionally be seen closely attached to the cells in those very exceptional cases in which epithelium can be detected in choleraic discharges, as well as very frequently in connection with the loose epithelium found in the intestines after death, as figured and described in the last report.*

These observations on the blood, especially when taken in connection with the light which they throw on the nature of the cells and bioplasts of the evacuations, do not tend to indicate the presence of a microscopically demonstrable morbid poison in either medium, they merely show that the escape of materials from the blood is sufficient to account for the presence of the most remarkable and constant microscopic features in the evacuations.

B.—Results of microscopic examinations of the blood in health and in diseases other than cholera.

Preliminary observations were made with normal blood.

As might be supposed, these systematic observations on the blood in cholera were not commenced without our having, as we thought, made ourselves practically conversant with all the changes discernible in normal blood; indeed, on referring to our notes, we find that daily, and in several cases hourly, observations had been entered relative to about three dozen specimens examined in precisely the same manner as the foregoing, but in none of them is there any allusion to the phenomena just described. Whereas in the written description of the second case of the cholera-blood series, we find it entered on the fourth day that "the serous portion of the specimen is crowded with granular, white corpuscles, extremely like pus-cells." Then follow careful notes of between sixty and seventy specimens in which the various stages above summarised are minutely described.

The changes occurring in normal and cholera blood are, to a certain extent, identical.

Thinking that it might by no means be impossible that similar changes might have been overlooked in the normal blood series, we determined to go over this ground again, and found this to have been the case, to a certain extent at all events, in some samples of blood. Still even in these exceptional cases the difference is so marked that we almost venture to state that, given two samples of blood, one being choleraic and the other healthy, although to the naked eye, or at first sight under the microscope, no difference might be discerned, we could pretty accurately state on the second day to which of the two sources the specimens should be referred.

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* Seventh Annual Report of the Sanitary Commissioner with the Government of India: Appendix B, Plate III.

Similar amœboid corpuscles may very readily be detected creeping out of the blood clot in this climate without any special artificial arrangements being adopted to raise the temperature even in healthy blood; but in no single case have we hitherto seen them appear in anything like the same proportion as in the blood obtained from patients suffering from cholera, where not infrequently little white spots about the size of a millet-seed may be seen with the naked eye, which, when placed under the microscope, will be found to correspond with aggregations of these pus-like corpuscles. Added to this the corpuscles appear to be smaller and to disintegrate much more readily in normal blood; so much so that in the course of about twenty-four hours nothing special is to be observed, merely the usual proportion of white cells, with possibly some aggregations of molecules and a few hyaline cells, regarding the origin of which no conjecture could have been arrived at, had the earlier changes undergone by the preparation not been carefully watched; whereas in cholera these amœboid bodies, after they have become spherical, may, as has already been intimated, persist for several days without any marked change.

Whether this persistency be owing to the increased density of the blood in cholera, or to the character of the bodies referred to, we are not in a position to state; nor would we for a moment wish it to be inferred that any specific character can be attributed to them, but it is evident that the blood in cholera is particularly adapted to their development, or at any rate to their being readily recognized and well preserved.

The blood in diseases other than cholera.

We have examined the blood in other diseases, and in such exceptional diseases as tetanus, but have failed to discover any such marked deviation from the normal standard in any single instance. Whilst examining some wax-cell preparations of the blood in a case of typhoid fever (the patient having been

Bacteroid bodies in typhoid fever;

for two days delirious), we were particularly struck with the marked diminution in the number of white corpuscles, which, in the course of a few hours, are usually seen in the ring of serum surrounding the clot in normal blood; and also by the constant presence of numerous interlacing vibrio or bacteria-like filaments along the edge of the preparation, stretching across from one cluster of red corpuscles to another. No movements whatever were exhibited by these bodies, which, in the course of a few hours, became slightly beaded, and eventually disappeared.

effect of osmic acid on them;

So closely did they resemble the low forms of life above referred to, that we were at first much puzzled as to their real nature; but on subjecting a perfectly fresh sample of the blood to the fumes of osmic acid in the usual way, we found that under these circumstances no trace of the existence of the delicate bodies referred to could be detected. We therefore inferred that their presence in specimens otherwise prepared was due to the separation of fibrine, which had not had time to take place to any great extent before the fluid was fixed by the osmic acid.

their resemblance to the "bacteridia" in "mal de rate".

The resemblance which these appearances bore to the description of the motionless *bacteridia* of Davaine, as occurring in the blood in "mal de rate" or malignant pustule, was very great; and we are strongly of opinion that the *bacteridia* so prominently set forth in connection with this malady, are not living organisms at all, but simply coagulated fibrine-filaments.

Non-appearance of leucocytes under certain circumstances.

Whilst this report was passing through the press, Dr. Bastian's very remarkable work* came into our hands, and we were much impressed by a reference made in it to the experiments of M. Onimus, which show that "neither leucocytes nor any other kind of anatomical elements" are produced in serum whose fibrine has been coagulated.

Possible reason for the paucity of leucocytes in typhoid fever, and for their abundance in cholera.

This possibly accounts for the remarkable paucity in the number of white-blood corpuscles in typhoid fever when examined as above described, and appears to us to verify to a great extent the opinion which we have formed as to the nature of the bacteroid bodies in the blood in typhoid fever, and of the *bacteridia* in "mal de rate." Possibly, also, the great number of the bioplasts which appear in the serum of the blood in cholera, may be due to a diminution in the normal coagulability of the blood.*

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* "The Beginnings of Life," 2 volumes: Macmillan and Co., 1872.

It has long been known that in pyæmia the smaller vessels and capillaries, especially near the parts affected, are frequently blocked up with what are believed by many to be aggregations of pus-cells in various stages of disintegration; but another school, with Virchow as one of its principal expounders, denies that these plugs are due to pus, but ascribes them to solid particles brought by the veins from the diseased tissue. Perhaps when the tendency in certain conditions of the blood to aggregation of particles of its plasma, in the manner described as occurring in cholera, becomes generally known, these views relative to the pus-like corpuscles in the small vessels may become materially modified. We have not as yet been able to obtain samples of blood from a patient suffering from pyæmia, but we may state that the nearest approach to the above described appearance of the blood in cholera was obtained in specimens of blood (examined by precisely the same method) from dogs, in whom a condition more or less approaching to pyæmia had been artificially produced.

The "pus-cells" described as occurring in the vessels in pyæmia, may be due to aggregation of bioplasts.

It is neither impossible, nor without some show of reason to infer, that the same tendency on the part of these plasma particles to leave the clot, and to become separated from the red cells, may exist in the living tissues; that a tendency to accumulation in the minute vessels and capillaries may occur in cholera; and that this, to some extent at least, may be the cause of the extreme difficulty with which the capillary circulation is evidently carried on in the course of this disease.

Possibility of the minute vessels being blocked up by bioplasts in cholera.

These suggestions we make with much diffidence, as we have not yet been able to test their accuracy by direct experiment. In such complicated investigations it is often extremely difficult to adduce positive proof of the truth of inferences which are yet so far founded on evidence that they deserve notice.

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* This conjecture appears to receive a certain amount of corroboration from the fact that in two slight cases of cholera the blood was observed to contain such fibrinoid filaments coincidently with an unusually small number of leucocytes.

The points in question will be made the subject of careful enquiry, but meantime it appears desirable that the possible accuracy of the views we have expressed should be recorded.

C.—Observations on the blood in connection with the question of monads and bacteria, of fungi and of sarcinæ.

Concerning the relation existing between low organisms and fermentation theories of disease.

Intimately associated with the zymotic theories of the production of disease, and notably of cholera, is the queston of the existence of monads, bacteria and such like organisms in the blood of the persons affected, either in such a condition as readily to be recognized, or in such an undeveloped state as to elude detection by the best objectives yet constructed. As to the former condition, we have already very emphatically expressed the conclusion which our observations have forced upon us, at least so far as the blood in cholera is concerned, namely, that no such bodies can be seen in this fluid, either during life or within a few hours after death as an invariable concomitant of the disease.

Possibility of low organisms being potentially present in the blood; methods adopted to test this question.

Whether or not such organisms may, nevertheless, be potentially present, is a question to which we have devoted a considerable portion of our time. In order to satisfy ourselves on this point, cursory examinations merely of any number of specimens of blood would have availed but little, consequently the plan already described for the *continuous* observation of preparations of this nature was adopted. Before starting, however, we satisfied ourselves that the amount of air present in the wax-cells resorted to was amply sufficient by inoculating samples of healthy blood with minute quantities of bacteria; and observing whether or not the latter could be seen to multiply as rapidly in these closed cells as in similar cells whose walls had been perforated in two or three places, so as to permit of the free ingress and egress of air, not the slightest difference could be observed. Fungi were also tested in the same way with identical results. Indeed, after the first few hours of observation, many of the preparations here referred to were thus ventilated, but this appeared to have no effect, save to render them more liable to invasion by fungi and acari.

Number of observations conducted.

We have preserved notes of one hundred and twenty-eight specimens of blood derived from various sources, each of which has been kept under observation for periods varying from three days to nearly three months. As, however, these would occupy so much space were they published in detail, we have tabulated the results in as simple a manner as we possibly could.

Tables showing the frequency with which Monads or Bacteria, Fungi, and Sarcinæ appeared during continuous observations of 22 *specimens of healthy human blood, and of* 57 *specimens of blood from cholera-patients,* 18 *of which were obtained after death.*

PREPARATIONS OF HEALTHY HUMAN BLOOD.								
		MONADS OR BACTERIA PRESENT*			FUNGI PRESENT**			SARCINÆ PRESENT.
Series No.	Preparation No.	At first.	Within 6 hours.	Within 24 hours.	At first.	Within 24 hours.	Within a week.	Within a fortnight.
1	1	No	No	No	No	No	No	No
..	2	,,	,,	,,	,,	,,	,,	,,
..	3	,,	,,	,,	,,	,,	,,	,,
2	1	,,	,,	,,	,,	,,	Yes	,,
..	2	,,	,,	,,	,,	,,	Yes	,,
3	1	,,	,,	,,	,,	,,	No	,,
4	1	,,	Yes	Yes	,,	,,	,,	,,
5	1	,,	No	No	,,	,,	,,	,,
6	1	,,	,,	,,	,,	,,	,,	,,
...	2	,,	,,	,,	,,	,,	,,	,,
..	3	,,	,,	,,	,,	,,	,,	,,
..	4	,,	,,	,,	,,	,,	,,	,,
7	1	,,	,,	,,	,,	,,	,,	,,
8	1	,,	,,	,,	,,	,,	,,	,,
9	1	,,	,,	,,	,,	,,	Yes	,,
10	1	,,	,,	,,	,,	,,	No	,,
11	1	,,	,,	,,	,,	,,	,,	,,
12	1	,,	,,	,,	,,	,,	,,	,,
13	1	,,	,,	,,	,,	,,	,,	,,
14	1	,,	,,	,,	,,	,,	,,	,,
15	1	,,	,,	,,	,,	,,	,,	,,
16	1	,,	,,	,,	,,	,,	,,	,,
Total	22	..	1	1	...	...	3	...

PREPARATIONS OF BLOOD IN CHOLERA DURING LIFE.								
		MONADS OR BACTERIA PRESENT*			FUNGI PRESENT**			SARCINÆ PRESENT.
Series No.	Preparation No.	At first.	Within 6 hours.	Within 24 hours.	At first.	Within 24 hours.	Within a week.	Within a fortnight.
17	1	No	No	No	No	No	No	No
...	2	,,	,,	,,	,,	,,	,,	,,
..	3	,,	,,	,,	,,	,,	,,	,,
..	4	,,	,,	,,	,,	,,	,,	,,
18	1	,,	,,	,,	,,	,,	Yes†	,,
..	2	,,	,,	,,	,,	,,	No	,,
..	3	,,	,,	,,	,,	,,	,,	,,
..	4	,,	,,	,,	,,	,,	,,	,,
..	5	,,	,,	,,	,,	,,	,,	,,
..	6	,,	,,	,,	,,	,,	,,	,,
19	1	,,	,,	,,	,,	,,	Yes	,,
20	1	,,	,,	,,	,,	,,	No	,,
...	2	,,	,,	,,	,,	,,	,,	,,
...	3	,,	,,	Yes	,,	,,	Yes	,,
21	1	,,	,,	No	,,	,,	No	,,
..	2	,,	,,	,,	,,	,,	,,	,,
..	3	,,	,,	,,	,,	,,	,,	,,
..	4	,,	,,	,,	,,	,,	Yes	,,
22	1	,,	,,	,,	,,	,,	No	Yes††
...	2	,,	,,	,,	,,	,,	,,	Yes††
..	3	,,	,,	,,	,,	,,	,,	No
..	4	,,	,,	,,	,,	,,	,,	,,
..	5	,,	,,	,,	,,	,,	,,	,,
..	6	,,	,,	,,	,,	,,	,,	,,
23	1	,,	,,	,,	,,	,,	,,	,,
..	2	,,	,,	,,	,,	,,	,,	Yes?
24	1	,,	,,	,,	,,	,,	,,	No
..	2	,,	,,	,,	,,	,,	,,	,,
25	1	,,	,,	,,	,,	,,	,,	,,
26	1	,,	,,	,,	,,	,,	,,	,,
..	2	,,	,,	,,	,,	,,	,,	,,
27	1	,,	,,	,,	,,	,,	,,	,,
...	2	,,	,,	,,	,,	,,	Yes	,,
28	1	,,	,,	,,	,,	,,	No	,,
29	1	,,	Yes	Yes	,,	,,	Yes	,,
30	1	,,	No	No	,,	,,	No	,,
31	1	,,	,,	,,	,,	,,	,,	,,
32	1	,,	,,	,,	,,	,,	,,	,,
33	1	,,	,,	,,	,,	,,	,,	,,
Total	39	...	1	2	...	..	6	3

PREPARATIONS OF BLOOD IN CHOLERA AFTER DEATH.								
		MONADS OR BACTERIA PRESENT*			FUNGI PRESENT**			SARCINÆ PRESENT.
Series No.	Preparation No.	At first.	Within 6 hours.	Within 24 hours.	At first.	Within 24 hours.	Within a week.	Within a fortnight.
34	1	No	No	No	No	No	No	No
35	1	,,	,,	,,	,,	,,	,,	,,
...	2	,,	,,	,,	,,	,,	,,	,,
36	1	,,	,,	,,	,,	,,	,,	,,
..	2	,,	,,	,,	,,	,,	Yes	,,
..	3	,,	,,	,,	,,	,,	No	,,
37	1	,,	,,	,,	,,	,,	,,	,,
..	2	,,	,,	,,	,,	,,	Yes‡	,,
..	3	,,	,,	,,	,,	,,	No	,,
38	1	,,	,,	,,	,,	,,	,,	,,
..	2	,,	,,	,,	,,	,,	Yes	,,
39	1	,,	,,	,,	,,	,,	No	,,
...	2	,,	,,	,,	,,	,,	,,	,,
..	3	,,	,,	,,	,,	,,	,,	,,
40	1	,,	,,	,,	,,	,,	Yes‡‡	,,
...	2	,,	,,	,,	,,	,,	No	,,
...	3	,,	,,	,,	,,	,,	,,	,,
..	4	,,	,,	,,	,,	,,	,,	,,
Total	18	...	..	...	...	...	4	...

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* Under this heading in this and succeeding Tables, only such molecules or staves are included as showed distinct evidence of vitality by form, growth or movement.

** These, unless otherwise, mentioned, refer to instances in which the fungal filaments manifestly invaded the preparation from without.

† The fungus seen to start from the centre of the clot.

†† The blood in these preparations had been mixed with a solution of acetate of potash and had been left unsealed.

‡ Penicillium.

‡‡ Penicillium and aspergillus heads were *distinctly seen* to be borne on branches arising from one and the same filament.

Absence of low organisms in blood even when no special precautions were adopted to keep them away.

It will be seen from the above table that the number of instances in which monads or bacteria appeared in the specimens of blood, whether in health or in cholera, before or after death, is very insignificant; indeed, in not a single instance is it recorded that any such organisms were present when examined immediately after it was obtained. It may be remarked that no extraordinary precautions were adopted, such as exposing the covering-glass or the needle to the flame of a spirit-lamp—very ordinary precautions indeed having sufficed to prevent contamination to any great extent with any low forms of life whatever. Of the 22 specimens of healthy blood examined, distinct evidence of monads or bacteria was only once observed, and fungal filaments only appeared on three occasions, or at the rate of about 13 per cent. In the blood of cholera patients obtained during life, monads or bacteria were only observed on two occasions in 39 specimens, and fungi were seen to develope in six preparations, just 2 per cent. more than in healthy blood. Except on one occasion, the fungus was observed to have entered the preparation from without, the filaments having insinuated themselves between the covering-glass and the ring of wax at a spot where apposition had not been perfectly effected; in the exceptional case the filament emerged from the clot, and was probably derived from a spore deposited on the covering-glass by the duster.

Absence of bacteria, &c., in the blood after death in cholera.

The absence of these low forms of life is equally conspicuous in the table of the cholera-blood preparations obtained after death. In the greater part of the specimens so obtained, a series had already been under examination during life. Of the 18 cases recorded, there was not a single preparation which manifested distinct evidence of bacteria, either on the first or succeeding days, and fungi developed on four occasions only.

The statement that sarcinæ normally exist in the blood not substantiated by these experiments. Possible nature of sarcinæ.

As to the presence of sarcinæ in the blood, which latterly have been alluded to (by Lostorfer and other observers) as being constantly present in this fluid, we can merely state that on two occasions only did we observe them make their appearance during our examinations of the preparations of blood here referred to; and it so happens that whereas six samples of the particular blood alluded to were under observation, only in the two specimens, to which a solution of acetate of potash had been added, did the sarcinæ appear. We have recorded another case as being of a questionable nature, the bodies observed having appeared to us to be more like crystals which had assumed a sarcinoid arrangement: indeed, from what we have observed of sarcinæ under other circumstances also, we incline strongly to the opinion that they are crystalline rather than organised bodies.

Experiments to ascertain whether bacteria, &c., multiply when introduced into the circulation.

Having in our own minds become perfectly satisfied that none of the organisms above alluded to existed in the blood in a state of health, or in cholera, and having also observed that when ordinary blood was inoculated with monads or bacteria, their multiplication and activity usually ceased in the course of two or three days, unless fresh material were added, we were still anxious to ascertain whether they would increase in a more marked degree, and whether their period of activity would be prolonged by being introduced into the circulation. With the view of attempting to clear up this matter, decomposing solutions swarming with monads, bacteria and vibriones were injected into the veins of dogs, a sample of the blood being in most instances previously examined for the sake of comparison, and the animals slaughtered at periods varying from a few minutes to a week after the operations. Our note book contains a record of forty-nine such experiments which we thus briefly epitomise:—

Table showing the result of experiments to ascertain how long after the introduction of putrefying matter into the blood, bacteria, &c., could be detected.

Series No.	Preparation No.	PERIOD EXPIRED SINCE		MONADS OR BACTERIA PRESENT			FUNGI PRESENT			SARCINÆ PRESENT		
		The last operation.	A former operation.	At first.	Within 6 hours.	Within 24 hours.	At first.	Within 24 hours.	Within a week.	At first.	Within 24 hours.	Within a fortnight.
1	1	2 minutes ...	......	no	no	yes	no	no	no	no	no	no
...	2	,, ,, ...	......	yes	yes	,,	,,	,,	,,	,,	,,	,,
2	1	15 ,, ...	......	no	,,	,,	,,	,,	,,	,,	,,	,,
...	2	,, ,, ...	......	,,	no	,,	,,	,,	,,	,,	,,	,,
...	3	,, ,, ...	......	,,	,,	,,	,,	,,	,,	,,	,,	,,
...	4	,, ,, ...	......	,,	,,	,,	,,	,,	,,	,,	,,	,,
3	1	2 hours ...	......	,,	,,	no	,,	,,	,,	,,	,,	,,
...	2	,, ,, ...	......	,,	yes	yes	,,	,,	,,	,,	,,	,,
...	3	,, ,, ...	......	,,	no	no	,,	,,	,,	,,	,,	,,
...	4	,, ,, ...	......	,,	,,	,,	,,	,,	,,	,,	,,	,,
4	1*	6 ,, ...	......	,,	,,	,,	,,	,,	,,	,,	,,	,,
...	2*	,, ,, ...	......	,,	,,	,,	,,	,,	yes	,,	,,	,,
5	1*	7 ,, ...	......	,,	,,	,,	,,	,,	no	,,	,,	,,
6	1	8 ,, ...	......	,,	,,	,,	,,	,,	,,	,,	,,	,,
7	1	,, ,, ...	......	,,	,,	,,	,,	,,	,,	,,	,,	,,
8	1	9½ ,, ...	......	,,	,,	,,	,,	,,	,,	,,	,,	,,
...	2	,, ,, ...	......	,,	,,	,,	,,	,,	,,	,,	,,	,,
9	1	11 ,, ...	......	,,	,,	,,	,,	,,	,,	,,	,,	,,
...	2	,, ,, ...	......	,,	,,	,,	,,	,,	,,	,,	,,	,,
10	1	14 ,, ...	......	,,	yes	yes	,,	,,	,,	,,	,,	,,
11	1	15 ,, ...	......	,,	,,	,,	,,	,,	,,	,,	,,	,,
...	2	,, ,, ...	......	,,	,,	,,	,,	,,	,,	,,	,,	,,
12	1*	,, ,, ...	......	yes	,,	,,	,,	,,	,,	,,	,,	,,
13	1	20 ,, ...	......	no	no	no	,,	,,	,,	,,	,,	,,
14	1*	23 ,, ...	......	yes	yes	yes	,,	,,	,,	,,	,,	,,
15	1	24 ,, ...	3 and 5 days ...	no	no	no	,,	,,	yes	,,	,,	,,
16	1	,, ,, ...	......	,,	,,	,,	,,	,,	no	,,	,,	,,
17	1	,, ,, ...	......	yes	yes	yes	,,	,,	,,	,,	,,	,,
...	2	,, ,, ...	......	no	,,	,,	,,	,,	,,	,,	,,	,,
18	1*	,, ,, ...	......	,,	no	no	,,	,,	,,	,,	,,	,,
19	1	2 days ...	......	,,	,,	,,	,,	,,	,,	,,	,,	,,
...	2	,, ,, ...	......	,,	,,	,,	,,	,,	yes	,,	,,	,,
...	3	,, ,, ...	......	,,	,,	,,	,,	,,	,,	,,	,,	,,
...	4	,, ,, ...	......	,,	,,	,,	,,	,,	no	,,	,,	,,
20	1	,, ,, ...	......	,,	,,	,,	,,	,,	,,	,,	,,	,,
21	1	,, ,, ...	4 days ...	,,	,,	,,	,,	,,	,,	,,	,,	,,
22	1	,, ,, ...	5 ,, ...	,,	,,	,,	,,	,,	,,	,,	,,	,,
23	1	,, ,, ...	6 ,, ...	,,	,,	,,	,,	,,	,,	,,	,,	,,
24	1	3 ,, ...	......	,,	,,	yes	,,	,,	,,	,,	,,	,,
25	1*	,, ,, ...	......	,,	,,	no	,,	,,	,,	,,	,,	,,
26	1*	4 ,, ...	6 days ...	,,	,,	,,	,,	,,	,,	,,	,,	,,
...	2*	,, ,, ...	,, ,, ...	,,	,,	,,	,,	,,	yes	,,	,,	,,
27	1	,, ,, ...	......	,,	,,	,,	,,	,,	no	,,	,,	,,
...	2	,, ,, ...	......	,,	,,	,,	,,	,,	,,	,,	,,	,,
...	3	,, ,, ...	......	,,	,,	,,	,,	,,	,,	,,	,,	,,
28	1	,, ,, ...	......	,,	,,	,,	,,	,,	,,	,,	,,	,,
29	1	,, ,, ...	......	,,	,,	,,	,,	,,	,,	,,	,,	,,
30	1	7 ,, ...	......	,,	,,	yes	,,	,,	,,	,,	,,	,,
...	2	,, ,, ...	......	,,	,,	no	,,	,,	,,	,,	,,	,,
Total...	49	....	... ..	4	10	16	0	0	5	,,	,,	,,

* Preparations thus marked indicate that they were obtained after the death of the animal.

Bacteria, &c., do not multiply when introduced into the circulation,

It will be seen from this table that the minute organisms, with which decomposing organic solutions swarm, do not multiply on being introduced into the blood of healthy or diseased animals; for it must be borne in mind that the blood of several of the dogs experimented upon had, on a previous occasion, or even on two occasions, been contaminated in a similar manner, and could consequently scarcely be designated healthy.

Indeed, not only is it shown that the organisms under consideration cease to multiply under such circumstances as these, but that they actually diminish in number every hour they remain in the system, and eventually disappear altogether.

but gradually disappear.

Out of twelve preparations of blood obtained from animals within six hours after the introduction of putrefying matter into their veins, active monads and bacteria were present in seven of them, or at the rate of about 58 per cent.; and out of thirty preparations examined, under similar circumstances within twenty-four hours, they were distinctly recognized in fourteen, or something under 47 per cent.; whereas, in nineteen specimens of blood derived from animals who had been inoculated in this manner from two to seven days previously, these bodies could only be detected in two of them, or only at the rate of about 10½ per cent., just 6 per cent. higher than was observed to be the case in healthy blood, which we have attributed to accidental circumstances.

It may be noted that in four of the dogs whose blood had been infected on two occasions each, the blood, when examined within four, five and six days of the first infection, did not present a trace of these organisms.

What becomes of these organisms?

What becomes of them we are not in a position to state. Whether they become disintegrated or dissolved in the warm serum, or become merely filtered off during their passage through the tissues and glands, is a subject we hope satisfactorily to settle before long. In the meantime it may be remarked that we examined fluid expressed from the axillary and mesenteric glands in the greater number of the cases above tabulated (and in the same way), and have found that bacteria could be detected in them, especially in the mesenteric glands, at later periods than in the blood, but have noticed them absent, after a time, in these also.

What relation do they bear to contagion?

As to whether these motile molecules, or staves, are themselves the cause of the disturbance which takes place in the system, consequent on the introduction of putrefying material into the blood (as will be fully referred to in a subsequent chapter), or whether they are merely the indicators that fluid containing them possesses this property, or indeed whether their presence at all is of any moment, we must for the present defer discussing. It will, however, be evident, on perusal of our notes of experiments on animals further on, that the question must have been constantly pressed upon our attention.

PART II.

EXPERIMENTS ON THE INTRODUCTION OF ORGANIC FLUIDS INTO THE SYSTEM.

Experiments on lower animals prescribed by the Army Sanitary Commission.

We had deferred taking up systematically that portion of the programme, drawn up for our guidance by the Army Sanitary Commission, relating to the experiments which should be carried out on lower animals in the conduct of this enquiry until the present year, as we did not feel that our knowledge of the various stages through which persons suffering from cholera have to pass, and of the *post-mortem* appearances associated with the disease, was sufficiently exact to enable us to conduct observations of this nature with profit.

Approximate number of dogs experimented upon.

It need scarcely be mentioned that every means was adopted to inflict as little pain as possible on the animals which have passed through our hands, considerably over a hundred dogs, together with several animals of a smaller kind.

Anæsthetics invariably resorted to before the commencement of the examination.

Chloroform has invariably been resorted to: in no single instance has any animal been slaughtered except when thoroughly under its influence; and when, as in some of the experiments, considerable pain would have been inflicted by allowing the animal to recover from the effects of the anæsthetic before the experiment was concluded, it has been kept under its influence during the whole period of operation, two or three hours, as the case may have required.

Objections to the use of very small animals owing to the high mortality from chloroform,

At the commencement of these observations small animals were selected, such as rats, rabbits, or rather hares, for rabbits are not obtainable here; but we found the administration of chloroform so very frequently proved fatal with such animals, that they had to be abandoned. The same fatality was observed in connection with puppies and young dogs: indeed, even in dealing with large healthy dogs we calculate on losing about one in five through this cause alone. Moreover, the effects produced were of so contrary a character, even under precisely similar conditions, that we feel convinced that any data of this kind obtained by experiments on small and delicate animals are extremely liable to mislead.

and uncertainty of result.

This is a very unfortunate circumstance, not only because, as a rule, small animals are more easily obtained and more manageable, but also because the observations on cholera-material hitherto recorded, and which have exercised great influence on the opinion of medical writers, and of the scientific world generally, have for the most part been derived from experiments on even more delicate animals than those above referred to.

This drawback will be evident to all who may carefully peruse some of the following cases, more especially those recorded in connection with the attempts to produce infection by the introduction of choleraic and other organic matters into the circulation.

Unsuitableness of small animals for nerve-section experiments.

The unsuitableness of small animals for experiments involving section of minute and deep-seated nerves arises, to a great extent at least, from a different cause, namely, the extreme tenuity of nerve fibres in such, which in man are large and easily accessible, and are even moderately large in well-developed dogs. Size is of still more importance, where, as in remarkable cases to be afterwards referred to, the section of a certain portion of a nerve appears to make such a vast difference in the result of the experiment.

Reasons for having selected dogs for these purposes.

We have, therefore, selected the dog not only from its size, but also from the fact of its food being very closely allied to that of man, as being more suitable to experiments of the nature here alluded to, especially as the organic substances hitherto experimented upon have not been introduced into the circulation through the digestive system. Had such a method been adopted, the tremendous powers of digestion of the native, pariah or Bedouin dog would have rendered any comparative data unmistakeably use-less.* Added to this, the numbers obtainable and with tolerable ease (these dogs being under the ban of the Police here), it will be evident that, taking all things together, they are the most suitable animals for systematic investigations of this nature.

A.—Experiments on the injection of choleraic and other organic fluids into the veins of animals.

Condensed details of the experiments are given, not only because of their connection with the subject of the report,

In order to judge of the validity of generalizations derived from any such series of experiments as that included under the above heading, it is clearly necessary that the precise grounds for these should be known. We shall therefore, in the first place, proceed to give a brief abstract of the results of various cases, condensed from notes taken at the time, and shall then proceed to draw any conclusions from them which the data appear in our estimation to warrant.†

but also of their possible relation to other pathological conditions.

We are the rather inclined to such a course, seeing that almost any series of careful experiments on animals has not merely a direct bearing on the point immediately at issue, but ought at the same time to be capable of throwing numerous side lights on other subjects of physiological and pathological interest.

Classification of the experiments adopted.

In proceeding to give a detailed account of the result of individual experiments, some more or less systematic arrangement of them is essential. The experiments in question, in this instance, might be classified on various principles; but an arrangement having as its basis the fact of the purity or dilution of the medium employed, and sub-divided according to the age of the material, in other words according to the amount of decomposition which it has undergone, appears to be as natural and as convenient as any. Such an arrangement has accordingly been adopted in regard to the experiments of which we now proceed to give an account.

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* We purpose, however, availing ourselves of an early opportunity of trying the effect of injecting various substances directly into the small intestines of animals, by taking out a loop of the gut, and introducing the selected substance by means of a finely-pointed syringe; thus overcoming this source of fallacy, at least as far as the direct action of the stomach is concerned.

† In order to economise the time of the reader, we have endeavoured to render the marginal notes a convenient epitome of the salient points of each experiment.

1.—EXPERIMENTS ON THE INJECTION OF PURE CHOLERAIC FLUIDS INTO THE VEINS OF ANIMALS.

(a). The choleraic material used being fresh.

Appearance of the choleraic material injected.

EXPERIMENT I.—A large healthy pariah dog was put under chloroform, and nearly an ounce of choleraic evacuation was injected into the right femoral vein. The material injected consisted, in greater part, of grey watery fluid, but contained in addition numerous minute fragments of the flocculi characteristic of choleraic evacuations. The operation was performed at 8 A. M.

Effects of injection.

The animal continued dull and sluggish throughout the course of the day, but did not show the slightest indication of pain. It neither was purged nor vomited, and on the following morning, 24 hours after the operation, it appeared to be much livelier than on the previous evening. The wound in the thigh, however, presented an unhealthy aspect, and there was a considerable amount of swelling around it. The animal became rapidly more depressed and dull during the day, and in the evening appeared to be in a dying condition; but throughout it showed not a single symptom which could be supposed to resemble those of cholera.

As it appeared probable that it would die during the night, and that the results of *post-mortem* examination would therefore be vitiated, it was anew put under chloroform at 5 P. M., 33 hours after the injection, and the administration continued until respiratoin ceased. An immediate *post-mortem* examination was then performed, the results of which were as follows:—

Post-mortem appearances; nothing special observed.

There was much erysipelatous inflammation of an unhealthy nature around the wound extending for some distance up the flank. On opening the abdomen, the peritoneal cavity was found to contain no fluid, and the peritoneum both in its visceral and parietal layers appeared to be perfectly healthy. The intestines were empty, and in every respect appeared to be perfectly healthy. The liver was extremely fatty, and so soft and friable as to break under the slightest pressure. On its upper surface there was a radiating cicatrix which, from its appearance, seemed to indicate the site of an old rupture of the organ. The larger veins contained fluid blood, and there was no indication of the occurrence of embolism in

Absence of bacteria in the blood.

any part of it. The kidneys were extremely fatty, and the left one contained one or two embolic masses of considerable size, projecting on the surface and extending deeply into its substance. The bladder was full of urine. The pleuræ, lungs, and heart were perfectly normal in aspect. The blood showed no traces of bacteria in it when carefully examined a quarter of an hour after its removal from the heart.

(*b.*) *The choleraic material used being* ONE *day old.*

Material injected twenty-four hours old.

EXPERIMENT II.—A dog which had been previously the subject of injections of choleraic media, both femorals and one basilic vein having been previously tied (*vide* Experiments VI., XXXVI. and XL.), but which was nevertheless in very fair condition, was put under chloroform at 7-30 A. M. The remaining basilic vein was now opened, and four drachms of a choleraic evacuation passed by a patient in hospital 24 hours previously, and which had remained in a bottle during the interval, was injected into it.

No visible result.

The animal rapidly recovered from the effects of the chloroform, and, saving that it limped slightly in walking, appeared to be in no way affected by the operation. It continued apparently in health throughout the day, walking about and feeding, and on the following morning also it showed no symptoms of illness. It was therefore killed under chloroform as in the previous experiment, and an immediate *post-mortem* examination performed.

Post-mortem — no special lesion.

There was a localized sac of pus in the sheath of the vessel last injected. The pus appeared to be perfectly normal, and there was little inflammation around the sac. The wounds caused by the previous operations were clean and healthy, that in connection with the femoral vein of the opposite side being almost entirely healed up. The abdominal and thoracic organs were carefully examined, but save for the existence of one or two minute, congested, possibly embolic patches in the liver they appeared healthy and normal.

Material 24 hours old.

EXPERIMENT III.—A healthy young pariah dog was put under chloroform at 7 A. M., and four drachms of choleraic evacuation, which had stood for 24 hours in a bottle, was injected into the right femoral vein. The operation was performed on the same morning and with the same material as Experiment II.

The animal once or twice ceased to respire during the operation, but, by resorting to artificial respiration, sensibility was restored, and it eventually recovered from the influence of the chloroform.

Several days of illness supervened, during which the animal appeared hardly able to walk, became much emaciated, and was affected with slight convulsive twitchings. These symptoms gradually passed off, and at the close of a week after the performance of the operation, it appeared to have entirely recovered. It was accordingly killed on the morning of the eighth day, and an immediate *post-mortem* examination made.

Effects of operation; severe illness, but apparent recovery in a week.

On opening the abdomen the peritoneal cavity was found to contain a considerable quantity of reddish serous fluid. The intestines were congested externally, and contained here and there patches of reddish mucus. The remaining abdominal and thoracic organs appeared to be perfectly healthy.

Post-mortem: reddish fluid in peritoneum; intestines congested externally and containing pinkish mucus.

(*c.*)—*The choleraic material used being* TWO *days old.*

EXPERIMENT IV.—A large, healthy, young pariah dog was put under chloroform, and about half an ounce of choleraic material was injected into the right femoral vein. The material employed consisted of the supernatant fluid of an evacuation, which had stood for 40 hours, and which had, when quite recent, been chiefly characterised by the profusion of large, active amœboid bodies present in it.

Material used being the supernatant fluid, 40 hours old.

The dog rapidly recovered from the influence of the chloroform, and appeared to be quite unaffected by the operation. On the following morning, 24 hours after the injection, there were no symptoms of illness, and during the subsequent three days the animal appeared to be in perfect health, so that, on the morning of the 4th day from the first operation, he was made the subject of another experiment (*vide* Exp. XXII).

No result.

EXPERIMENT V.—A very young and healthy pariah pup was put under chloroform, and two or three drachms of the supernatant fluid from a choleraic evacuation

The supernatant fluid used, 48 hours old.

which had stood in the laboratory for 48 hours were injected into the right femoral vein.

No result.

The animal recovered rapidly and perfectly from the influence of the chloroform. It showed no symptoms of illness, and on the following day appeared to be quite well. As it continued in perfect health, it was subjected to a fresh operation 48 hours after the performance of the former one (*vide* Exp. XXXV).

Material used 48 hours old.

EXPERIMENT VI.—A healthy pariah dog, into the right femoral vein of which choleraic material had been injected three days previously without result, was put under chloroform, and four drachms of a dejection, which had been passed 48 hours before by a patient who had been ill for 24 hours, was injected into the femoral vein of the opposite side.

No result.

The dog was never fully under the influence of the chloroform, and very soon appeared as though nothing had happened to it. On the following day it seemed to be quite well and remained so until after the lapse of three days, when it was again operated on (*vide* Experiment II).

(*d.*)—*The choleraic material used being* THREE *days old.*

Material used 72 hours old, swarming with bacteria and animalculæ, obtained from a very mild case of cholera.

EXPERIMENT VII.—A strong, healthy pariah dog was put under the influence of chloroform, and four drachms of choleraic fluid was injected into the left femoral vein. The fluid was derived from an evacuation which had been kept for 72 hours.* It was watery, and at the time of the operation had but a very slightly offensive odour and a faint alkaline re-action. There was hardly any sediment present, and the material injected consisted entirely of liquid crowded with very large and active, stiff-looking bacteria, together with myriads of active flagellated monads.

No marked result: killed under chloroform 24 hours after operation.

The animal appeared to be very little affected by the operation, showed no symptoms of disease throughout the day, and by the following morning seemed to be quite well. Chloroform was accordingly again administered, and continued until death occurred 24 hours subsequent to the performance of the injection.

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* The case from which it was derived was a very slight one, rather of choleraic diarrhœa than of cholera, and made a rapid recovery.

Post-mortem: no peritonitis; intestines healthy.

A *post-mortem* examination was performed at once, the abdomen being opened before respiration and circulation had finally ceased. There were no signs of peritonitis present. The mucous surface of the intestines appeared to be quite healthy. Scrapings from it showed merely normal epithelial cells and villi with the usual sprinkling of minute bacteria. The mesentric glands were congested and contained a good deal of fluid in their interior. A preparation of this fluid was mounted in a wax cell and examined one hour and a half afterwards. It was found to consist of a clear liquid, containing no recognisable bacteria or vibriones, but full of red blood-corpuscles and active amœboid bioplasts. It was again carefully examined 24 hours later, but the only change observable in it was that the bioplasts had all become motionless and circular. The rest of the abdomen and thoracic organs were apparently healthy.

Mesenteric glands congested; contained no bacteria, nor did they develop in 24 hours.

No bacteria in the blood, nor were any developed.

Two preparations of blood from the heart were mounted as usual in wax cells. These were examined about an hour afterwards, and again after the lapse of 24 hours. On neither occasion did they show anything abnormal, the serum was perfectly clear and free from all traces of bacteria or vibriones, and an abundance of leucocytes crawled out of the clot and subsequently underwent their usual changes.

Material used, 72 hours old, same as in last experiment.

EXPERIMENT VIII.—Immediately after the injection of the previous experiment had been completed, another very large healthy pariah dog was put under the influence of chloroform, and six drachms of the same fluid was injected into the right femoral vein.

Death in 3 hours.

The animal rapidly recovered from the influence of the chloroform, and did not at first appear to be much affected by the operation, being able to walk to the kennel with apparent ease. It rapidly, however, became much depressed, and died within three hours. A *post-mortem* examination was performed five hours after death.

Post-mortem. No peritonitis; small intestines pale externally, and the mucous surface coated with a pinkish substance, consisting chiefly of epithelium, which had become almost entirely detached.

Post-mortem rigidity was strongly marked. On opening the abdomen there were found to be no signs of peritonitis. The small intestine was pale externally. On opening it, it was found to be coated with a thick soft substance of pink hue. This layer was quite loose and easily removed from the subjacent mucous membrane, and was found to be composed of detached epithelium. When it was washed off, the denuded surface of the membrane became visible, from which only a very little material could be scraped, consisting of imperfectly developed epithelial cells, and containing an abundance of very long, uniseptate or jointless vibriones, lying motionless or progressing in a serpentine fashion over the field, as represented in the woodcut (Fig. 1, page 34).

Beneath which were numerous oscillatoria-like vibriones.

Exemption of ileo-cœcal portion of small intestine.

For about six inches immediately above the ileo-cœcal valve the gut appeared quite healthy and unaffected, but every where else the epithelial coating of the mucous membrane appeared to be detached.

Mesenteric glands crowded with oscillatoria-like vibriones.

The mesenteric glands were soft, and not congested, but of a dirty yellow colour on section, and containing an abundance of fluid. A preparation of this fluid was mounted in a wax cell and carefully examined an hour and a half afterwards. It was found to contain an abundance of gland-cells and to be swarming with elongated vibriones like those present in the intestines, for the most part uniseptate, and either still or only moving slightly. It was again examined sixteen hours subsequently, but no changes had taken place in the condition of the vibriones, although the majority of the gland-cells had broken down, and numerous clusters of fatty crystals had made their appearance.

The large intestine healthy.

The large intestine was normal in appearance, and the remaining abdominal organs were healthy. The stomach contained a little glairy fluid.

No pleurisy; slight congestion of pericardium.

On opening the thorax there was found to be no pleurisy. The lungs were collapsed, the left one totally so, whilst the right was partially congested. The pericardium contained a little fluid, and there was slight congestion of both the visceral and parietal layers. The heart was healthy.

No bacteria in the blood, but needle-shaped crystals rapidly formed.

A preparation of blood from the right ventricle was mounted in a wax-cell and examined an hour afterwards. At that time no bacteria could be detected in it, but crystals had begun to appear, and the serum was stained with the colouring matter of the red-corpuscles, whilst sixteen hours afterwards the whole of the preparation was converted into a mass of large blood-crystals.

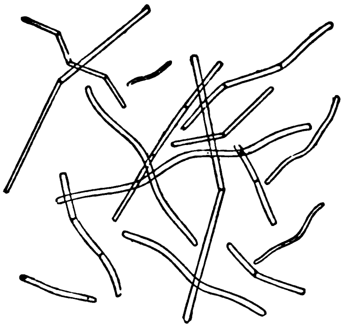

Fig. 1. ×500.
Oscillatoria-like vibriones obtained on the mucous surface of the small intestines and in the mesenteric glands.

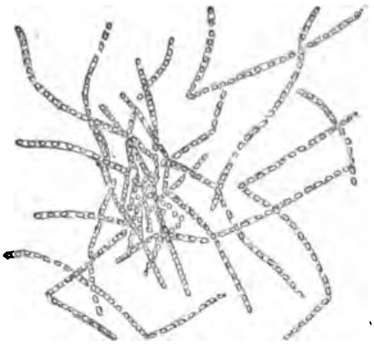

Fig. 2. ×500.
Appearances presented by the bodies in Fig. 1 on the third day.

Material used, same as last experiment, 72 hours old.

Experiment IX.—On the completion of the preceding operation, Experiment VIII, another very large pariah dog was put under the influence of chloroform, and one ounce of the fluid employed in it was injected into the right femoral vein.

Death in 4 hours.

The animal at first appeared to be very little affected, and, like the dog of the preceding experiment, walked off to the kennel with ease and without manifesting any symptoms of pain or inconvenience. It died, however, within four hours, and a *post-mortem* examination was performed four hours after death.

Post-mortem: no peritonitis; paleness of intestines externally; creamy substance within consisting of detached epithelium.

Post-mortem rigidity was strongly marked. On opening the abdomen the small intestines were found to present precisely the same appearances, both externally and internally, as in the preceding case. There was the same separation of the epithelium, and the resulting formation of a soft, pink, creamy substance, and in this case also the portion of the gut immediately above the ileo-cœcal valve was apparently unaffected.

Watery fluid towards lower end of ileum just above unaffected portion of mucous membrane, near ileo-cœcal valve.

The only feature in which the intestines in this instance differed from the others consisted in there being a certain amount of watery fluid present in them. Towards the lower end of the ileum, just above the unaffected portion of the mucous membrane, the separation of the epithelium was not so far advanced as higher up, and appeared to be in a state of transition towards such a condition.

Mesenteric glands contained bacteria and long vibriones.

The mesenteric glands were highly congested internally, of a soft consistence, and contained an abundance of pink fluid. A preparation of this fluid was mounted as usual in a wax-cell. When examined an hour and a half subsequently, it was found to contain an abundance of minute bacteria, a sprinkling of the long vibriones occurring in the glands and intestines of the previous case, together with normal gland-cells and numerous red blood-corpuscles. Sixteen hours later, it contained an abundance of minute active bacteria, together with molecular matter, fatty crystals and cells, but showed none of the elongated vibriones previously present in it.

Large intestine healthy.

The large intestine and appendix vermiformis were normal in aspect, and the rest of the abdominal viscera appeared healthy. The bladder contained a little urine.

Cancerous nodules throughout the lungs; slight pericarditis.

On opening the thorax there were found to be numerous large cancerous nodules throughout the substance of both lungs, which were collapsed, but contained a little air. There was slight inflammation of the parietal pericardium, and the visceral layer also was somewhat injected.

Bacteria developed in the blood.

A preparation of blood was, as usual, procured from the right ventricle and mounted in a wax-cell. When examined about two hours afterwards, the serum was found to be deeply stained with the colouring matter of the red corpuscles, and to contain numerous minute active particles, but no distinct bacteria could be detected in it. Sixteen hours afterwards it was crowded with large blood-crystals and contained an abundance of minute active bacteria.

Material used, same as in Experiments VII–IX., 80 hours old.

Death in about 6 hours.

EXPERIMENT X.—A small healthy pariah dog having been put under the influence of chloroform, about three drachms of the same fluid employed in the three preceding experiments, but which had now been kept for nearly eight hours longer, was injected into the right femoral vein. The injection was performed at 4 P. M., and the animal died during the night. A *post-mortem* examination was performed at 7 A. M. of the following day.

Post-mortem. Mucous membrane of small intestine covered with a soft pink coating of detached epithelium, except above ileo-cœcal valve.

Post-mortem rigidity was well marked. There was a little reddish serum in the peritoneal cavity, but the intestines and mesentery were not congested. On laying open the small intestine, the interior was found to present the usual appearances, the portion immediately above the ileo-cœcal valve being unaffected, and the rest of it covered with a soft pink coating of detached epithelium.

The pink material crowded with epithelial cells, and oscillatoria-like vibriones.

Preparations of this pink material as well as of matter scraped from the subjacent denuded mucous coat were examined. The former were found to consist of cylindrical epithelial cells, and to contain numerous long serpentine vibriones similar to those found in the intestines and glands of the dogs of the previous experiments. The latter preparations consisted of imperfectly developed epithelial cells, with an even greater abundance of the elongated vibriones (Fig. 1.) which ultimately resolved themselves into a network of leptothrix-filaments (Fig. 2).

Fluid in mesenteric glands contained long vibriones.

The mesenteric glands contained pinkish fluid, a preparation of which was mounted in a wax-cell. When examined an hour afterwards, the gland-cells were found to be considerably disintegrated, whilst the fluid contained great numbers of the elongated serpentine vibriones, described in the previous preparations, in a state of full activity. The majority of them appeared to be uniseptate with a kind of hinge joint in the middle.

The rest of the abdominal organs were healthy.

There was a little reddish serum in the pericardium; the right side of the heart was full of fluid blood, and the left contained a little also.

Blood contained active molecules, but no bacteria.

A preparation of blood was as usual mounted in a wax-cell, which was examined an hour and a half afterwards, and found to contain numerous minute molecules in active motion, but no distinct bacteria. Twenty-four hours afterwards it was crowded with large needle-shaped blood-crystals, and the serum had almost dried up.

(*d.*)—*The choleraic material used being* FOUR *days old.*

Material used as in Experiments VII-X, but 96 hours old.

EXPERIMENT XI.—A small healthy pariah dog was put under the influence of chloroform, and four drachms of the fluid employed in Experiments VII, VIII, IX and

X, but which had now been kept for 96 hours, was injected into the right femoral vein. The animal seemed to be very little affected by the operation, and ran off to the kennel very cheerfully a few minutes after it was completed. It remained in apparent health, and was killed under chloroform about 9 hours subsequently.

No marked effect. Killed under chloroform 9 hours after operation.

During the administration of the chloroform, tarry liquid escaped from the rectum, and the large intestine was subsequently found to be full of similar material. The small intestine for nearly two feet above the ileo-cœcal valve appeared healthy, but above that the mucous membrane was coated with a sanguineous layer, the epithelium however was not detached. The mesenteric glands were very much congested and full of reddish fluid. Some of them were reserved in a moist chamber for 14 hours. On sections being made at the close of that period, the gland was found to contain fluid in its interior swarming with active bacteria, and containing a sprinkling of long, active, serpentine vibriones similar to those found in the preceding experiments with the same fluid. A preparation of the fluid from the glands was also mounted in a wax-cell at the *post-mortem* examination. On examination a quarter of an hour afterwards, it was found to be full of red blood-corpuscles and crowded with minute motionless molecules. Twenty-four hours later many of these particles were in active motion, but there were no elongated vibriones present. The rest of the abdominal and thoracic viscera were healthy, and there were no traces of pericarditis.

Post-mortem. Upper portion of small intestine coated with a sanguineous substance, but the epithelium was not detached.

Mesenteric glands preserved for 4 hours contained bacteria and long vibriones :

Bacteria also present in gland fluid, but no vibriones developed.

Two preparations of blood, one from the vena portæ, the other from the right ventricle, were mounted in wax-cells as usual. They were examined a quarter of an hour afterwards ; the latter contained numerous motionless molecules, the former a few small blood-crystals, but in neither were there any distinct bacteria. They were again examined after an interval of 14 hours. At this time the preparation of portal blood contained numerous moving molecules, and an increased number of crystals, whilst the other preparation was apparently quite unchanged.

No bacteria in blood from heart or vena portæ, but moving molecules subsequently developed in the latter.

Material used 96 hours old.

EXPERIMENT XII.—A young and healthy dog was put under chloroform, and four drachms of choleraic dejection, which had been passed 96 hours previously, injected into the right basilic vein.

Death in 22 hours.

The animal came rapidly out of the influence of the chloroform, but its respiration was disturbed, violent and gasping. Towards the evening of the same day it began to pass reddish, mucous evacuations, and it continued to do so until 5 A. M. of the following morning, when it died, 22 hours after the operation.

Post-mortem appearances: Patches of red mucus in the small intestines.

A *post-mortem* examination was performed at 7 A. M. On opening the abdomen, the cavity was found to be free from fluid and the peritoneum was smooth and shining, appearing in every respect to be perfectly healthy. The large intestine was throughout coated with a layer of thick, dark red mucus which ceased sharply close to the ileo-cœcal valve. The small intestines showed small patches of red mucus on the interior of the jejunum and ileum, whilst the duodenum appeared to be perfectly healthy.

Small extravasations in the liver and

The liver contained a few extravasated spots of small size, and one about the size of an almond beneath the peritoneum close to the gall-bladder. The spleen was pale and bloodless. The kidneys appeared to be perfectly healthy.

in the lungs, which were also much congested; miliary spots on the surface of the heart.

On opening the chest the pleural cavities were found free of fluid, and the membranes, like the peritoneum, appeared perfectly healthy. The left lung was universally mottled and congested. It was gorged with blood, and exhibited numerous small spots of extravasation probably due to embolism, both superficially and throughout its substance. The right lung showed numerous blackish spots towards the base, but was not universally congested like the right one. The pericardium was healthy and contained no fluid. The surface of the heart, more especially of the left ventricle, was covered with yellowish white miliary spots, and small points of extravasation. The cavities of the right side were extremely distended and full of soft, black clot.

The left ventricle contained a little fluid blood.

Material injected (fluid and sediment), 96 hours old.

Death in about 15 hours.

Experiment XIII.—A healthy pup was put under chloroform, and three drachms of choleraic material injected into the left femoral vein. The material consisted of the fluid and sediment of an evacuation thoroughly shaken up, and was in an active state of decomposition, the fluid being covered with a thick layer of bacteria, and the sediment consisting in greater part of amorphous matter with a few persistent red blood corpuscles. The injection was performed at 9 A. M., and the dog rapidly came out of the influence of the chloroform. It died at midnight of the same day without having shown any choleraic symptoms.

Post-mortem appearances.

A few ecchymosed spots in jejunum and the ileum coated with reddish mucus.

A *post-mortem* examination was performed at 8 A. M. of the following morning, 23 hours after the operation. The *post-mortem* rigidity was well marked. There was no evidence of inflammatory action around the wound in the thigh, which appeared clean and healthy. On opening the abdomen, the cavity was found to be free of fluid, the surface of the small intestines appeared slightly roughened, but the parietal peritoneum was perfectly smooth and glistening, and there was no evidence of inflammatory action present. The stomach was empty, and there were a few ecchymosed spots on the mucous membrane. The duodenum appeared healthy and contained a small quantity of bile-stained mucus. The mucous membrane was perfectly free of injection throughout the upper portion of the jejunum, but towards the lower extremity there was an ecchymosed patch three or four inches in length. The ileum contained an abundance of mucus of a peculiar reddish hue. The large intestine was also coated with abundant reddish mucus.

Small nodules of disintegrated matter throughout the liver.

The liver both on the surface and throughout its substance showed numerous small, light coloured spots about the size of small shot. There were no inflammatory rings around them; after the specimen had been for 12 hours in a weak solution of spirit, these spots, where on the surface, appeared slightly prominent; but these prominences disappeared on exposure to the air, and slight depressions replaced them, appearing to indicate that they had been due to an abnormal absorption of fluid at these points. On microscopic examination, the material composing these light coloured spots was found to consist of molecular matter and liver-cells in various stages of disintegration. The spleen was normal in appearance. The kidneys also appeared healthy.

On opening the chest the pleuræ were found to be healthy. The trachea and bronchi were empty and normal. The lungs were collapsed, containing very little air. They appeared to be injected on the surface, contained a little black blood, and presented a somewhat pneumonic aspect. The smaller bronchial tubes contained a yellowish frothy fluid. The pericardium was healthy. The right auricle was distended with coagulum, part of which was black, part gelatinous and yellowish. The right ventricle was in a similar condition. The pulmonary artery was full of a similar coagulum. The left auricle contained a little dark clot and the left ventricle was strongly contracted and empty. The pulmonary veins were full but not distended with blood.

The thoracic viscera healthy (?).

Experiment XIV.—A small dog into both of whose femoral veins aqueous solutions of choleraic material had been previously injected without the slightest result (*vide* Experiments XXXIV & XXXVIII) was put under chloroform, and two drachms of the supernatant fluid of a dejection which had been kept for 96 hours were injected into the right basilic vein.

The material used (supernatant fluid), 96 hours old, crowded with bacteria and amœbæ. The dog had previously undergone two injections.

The material injected contained innumerable monads, bacteria and vibriones, together with a few amœboid bodies about the size of white blood corpuscles. The operation was performed at 7-30 A. M., and the dog quickly recovered from the influence of the chloroform, was able to support himself at once, and very shortly appeared as though nothing had happened to it. The animal continued in perfect health, eating and drinking freely and having certainly improved in condition during the period in which he had been subjected to operations involving the ligature of both femoral and one of the basilic veins.

No effect.

Previous to setting the dog at liberty, its blood was examined; neither monads nor bacteria discoverable.

Three days subsequent to the last operation, a specimen of blood was taken for microscopic observation, and the dog was then let loose to return to his native wilds, and no doubt to regret the regular diet and attention which he received during his period of service to science. The blood was carefully examined but without yielding the slightest evidence of the presence of monads, bacteria or vibriones.

Material used (supernatant fluid), 96 hours old.

Death in 5 hours.

Experiment XV.—A large healthy young dog was put under chloroform, and about seven drachms of the supernatant fluid of an evacuation which had been kept for 96 hours injected into the right femoral vein. Five hours subsequent to the operation the dog died somewhat suddenly, having passed about a pint of liquid evacuation just before death.

Post-mortem appearances; abdominal cavity; reddish fluid in peritoneum;

much congestion of some portions of the small intestines, with reddish fluid contents; small clots in the substance of the liver.

A *post-mortem* examination was performed four hours after death. The body was still warm, and there was no *rigor mortis*. On opening the abdomen, a little sanguineous fluid was found in the peritoneal cavity. The outer surface of the intestines was much congested and of a purple color. The stomach was healthy. The mucous surface of the duodenum was normal. The jejunum contained reddish-yellow frothy fluid, becoming pink towards the lower extremity; but there were no erosions of the mucous membrane. Towards the middle of the ileum the contents were of a sanguineous aspect and of fluid consistence, but they became paler towards the lower extremity. In the lower half of the ileum there were patches of extreme congestion corresponding, as a rule, with patches of *tricocephalus dispar*. Towards the ileo-cœcal valve the intestine appeared to be healthy. The large intestine exhibited a few ecchymosed spots, but was otherwise healthy in appearance. The liver was fatty and showed small clots penetrating its substance. The gall-bladder contained bile. The kidneys were slightly congested, but otherwise normal. The bladder contained about three ounces of clear urine.

Thoracic cavity; reddish fluid in pericardial and pleural cavities.

The pleural cavity contained a little slightly sanguineous fluid. The lungs were collapsed, containing very little air; but they were not congested. The pericardium contained about two ounces of fluid similar in appearance to that present in the peritoneal and pleural cavities. The right auricle and ventricle were full of dark colored clot.

Material used (supernatant fluid), 90 hours old: death in six hours.

EXPERIMENT XVI.—A healthy pariah dog was put under the influence of chloroform at 7 A. M., and half an ounce of the supernatant fluid of a choleraic evacuation* which had been kept for four days was injected into the right brachial vein. The fluid injected was peculiarly fœtid, and was full of fine granular débris and bacteria. The animal rapidly recovered from the influence of the chloroform, but continued in a profoundly depressed condition until about 1 P. M., when he died. During the interval he neither vomited nor passed any stool.

Post-mortem appearances:

Extreme congestion and disorganisation of the mucous membrane of the small intestines.

A *post-mortem* examination was performed at 4-30 P. M. *Rigor mortis* was strongly marked. There was no fluid in the peritoneal cavity; but there was a certain amount of injection of the omentum and mesentery with a good deal of dark pigmentary deposit in the same localities. The intestines were very pale, externally almost white. Throughout the entire course of the small intestines, from the pylorus to the ileo-cœcal valve, the mucous membrane was congested, softened, and apparently partially disorganised. It was coated with a thick layer of semi-fluid mucous material; and on this being wiped off, the surface beneath presented a brush-like aspect due to the injection of the villi. The material was, in some parts, yellowish-white; but in general was of various shades of pink and resembled strawberry-cream in appearance.

This creamy fluid, on microscopic examination, was found to consist almost entirely of perfectly preserved cylindrical epithelium.

On microscopic examination, it was found to be composed almost entirely of cylindrical epithelium mixed with bacteria and amorphous particles. The large intestine also contained pinkish mucus, but the membrane was not injected save along the edges of the rugæ. The stomach contained semi-digested food, and was slightly congested. Towards its pyloric extremity there was a very hard fibroid tumour apparently of a schirrous nature. The liver appeared healthy; there were numerous *distomata* in the bile ducts.* There were no traces of embolism throughout its substance. The gall-bladder contained bile. The spleen and kidneys were healthy. On opening the thorax, the pleural cavities were

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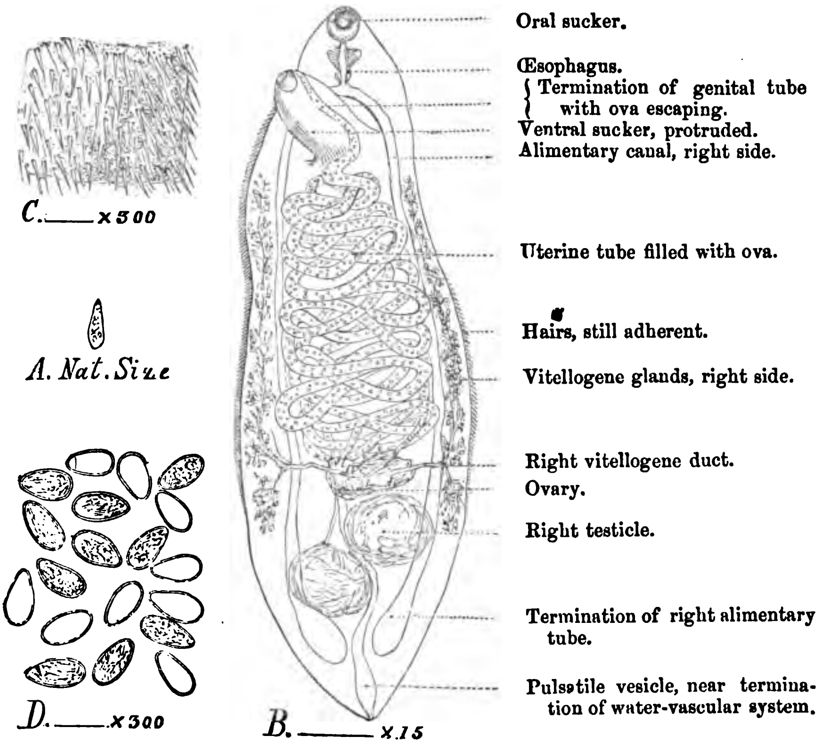
* This dejection was passed by a patient in the General Hospital. He was a sailor who had been in the harbour for only three days, and who had, previous to his seizure, never been over the side of the ship. The symptoms came on with extreme violence and suddenness, whilst he was in full health. The evacuations were *extremely* characteristic, and the term "rice-water" was peculiarly adapted to describe their appearance. That examined was passed two hours after seizure. On microscopic examination, the flocculi were found to consist entirely of brightly refractive cells, resembling those found in recent exudations, embedded in shreds of fibrinous material (so perfect was the resemblance that slides consisting of the flocculi and slides of quite recent flocculent exudation, removed from the surface of the liver, associated with peritonitis, when placed under separate microscopes could not be distinguished the one from the other); these cells in the course of a few hours broke down completely, whereupon the extraordinary resemblance which this dejection bore to rice-water disappeared.


C. x 300
A. Nat. Size
D. x 300
B. x 15
Oral sucker.
Œsophagus.
Termination of genital tube with ova escaping.
Ventral sucker, protruded.
Alimentary canal, right side.
Uterine tube filled with ova.
Hairs, still adherent.
Vitellogene glands, right side.
Right vitellogene duct.
Ovary.
Right testicle.
Termination of right alimentary tube.
Pulsatile vesicle, near termination of water-vascular system.

* Fig. 3, DISTOMA FOUND IN THE BILE DUCTS OF DOGS.
A.—The parasite figured natural size.
B.—Ditto magnified 15 diameters.
C.—Minute hairs covering the entire body when fresh and before being manipulated, magnified 300 diameters.
D.—Ova squeezed out of the uterine tube, magnified 300 diameters.

This distoma is not infrequently met with in the bile ducts of dogs in this country. With the limited supply of literature on this subject within our reach, we have, however, not been able to refer it to any described species, and have therefore introduced a wood-cut showing its size, form and minute anatomy, together with those of the ova. It appears to us to be very closely allied to the species discovered by Dr. Cobbold in the liver of the American red fox, and described and figured by him in his valuable work on Entozoa; indeed if, on re-examination it be found that that parasite has been, inadvertently, drawn by Dr. Cobbold as seen from the back—a mistake into which we ourselves fell, when the first specimen was sketched—this may turn out to be identical with the species described by this Author under the name of *Distoma Conjunctum.* We strongly suspect this to be the case.

Thoracic cavity; slight injection of pericardium.

found to be free of fluid, and the membranes appeared to be perfectly healthy. The lungs were collapsed, airless, and containing very little blood. The pericardium was slightly injected. The right cavities were distended with fluid blood, and the left side also contained a little blood.

Blood swarming with bacteria in the course of 12 hours.

Preparations of the blood were procured, and, whether under common covering glasses, or in hermetically sealed wax-cells, were found to be swarming with very active bacteria after the lapse of 12 hours.

Material used (supernatant fluid), 100 hours old: death in a few hours.

Experiment XVII.—A large healthy pariah dog was put under chloroform at 5 p. m. of the same day in which the preceding experiment was performed, and half an ounce of the same fluid employed in it injected into the right median vein. The operation was rapidly and successfully performed, and the animal quickly revived; but it appeared to be in a condition of profound collapse while under observation, and died during the course of the night, having passed some liquid mucous evacuations of a pink colour during the interval. The evacuations passed immediately after the operations were natural in colour and consistence.

Post-mortem appearances.

A *post-mortem* examination was performed at 7 a. m., 14 hours after the injection took place. *Rigor mortis* was strongly marked. Pinkish fluid* ran from the nose and mouth when the body was lifted. There was no evidence of peritonitis, and the external surface of the intestines was very pale, as in the preceding case. The stomach contained a little pale pinkish mucus; but the membrane beneath was not congested. The duodenum contained more abundant and more highly colored semi-fluid mucous matter, and the mucous membrane throughout the rest of the small intestines was softened, and coated with similar material. There were also small spots of extravasation throughout. The large intestine was not affected.

Disorganisation of the mucous membrane of the small intestines.

Intense congestion of mesenteric glands.

The mesenteric glands were all intensely congested and full of pinkish fluid closely resembling the intestinal material. The latter was found on microscopic examination to be composed of cylindrical epithelium mixed with abundance of bacteria and vibriones. The liver was variegated with light, yellowish, fatty spots. It contained no evidences of embolism. The kidneys and spleen were perfectly healthy. The bladder was empty. The pleural cavities were healthy, and the lungs were collapsed, pale and devoid of any traces of embolism. The pericardium was quite healthy. The right cavities of the heart were empty, and the left contained a little fluid blood. Preparations of blood were procured from the heart and from one of the systemic veins. These, when examined a quarter of an hour subsequently, showed no active bacteria, but a uniform sprinkling of minute motionless particles throughout the serum. Twenty-four hours subsequently the preparations were crowded with active bacteria.

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* The fluid consisted of mucus containing innumerable ova and a few perfect specimens male and female, of *Pentastoma tænioides*.

Thoracic cavity. No active bacteria in blood when removed from the heart, but numerous motionless particles and abundant active bacteria subsequently.

EXPERIMENT XVIII.—This experiment was performed at the same time and with the same material as the preceding one. A large healthy dog having been put under the influence of chloroform, four drachms of the fluid was injected into the right brachial vein.

Material used (supernatant fluid), 100 hours old, precisely as in the last experiment.

In consequence of a failure in the first attempt at injection and of the subsequent slipping of a ligature, the animal was both kept for some time under the chloroform, and moreover lost a considerable quantity of blood. The operation was at length, however, successfully performed. The dog seemed to be much depressed and whined as though in pain for some time.

Considerable loss of blood during the operation and extreme depression afterwards;

During the night, however, he improved greatly and drank some water; and on the following morning he ate and drank greedily, and seemed to suffer more from stiffness of the wounded limb than from any constitutional symptoms. The wound looked clean and healthy, and the animal was bright and lively in appearance. He continued free from any constitutional symptoms, and five days after the operation was set at liberty in full health and excellent spirits.

but the dog recovered completely in a few days and was set at liberty.

EXPERIMENT XIX.—A pariah dog of average size put under the influence of chloroform at 7 A. M., and four drachms of the

Material used (supernatant fluid), 96 hours old.

supernatant fluid of a choleraic evacuation which had been kept for 96 hours was injected into the right femoral vein. The dejection from which the material employed was derived was passed by a patient in the General Hospital whilst in profound collapse, and consisted almost entirely of watery fluid, only a very little flocculent sediment being present. These flocculi, when quite recent, showed mere flakes of minutely granular matter with a few hyaline cells and myriads of active infusoria. The material injected was entirely free from particles of sediment and consisted of an opalescent fluid swarming with active bacteria and containing a few molecular flakes and active ciliated infusoria. The operation was performed rapidly and with perfect success, and the dog quickly recovered from the influence of the chloroform. It passed a healthy evacuation soon after the close of the operation and showed no symptoms of pain, but extreme depression persisted, and it died about three hours after the operation, having neither vomited nor been purged during the interval.

Death in 3 hours.

A *post-mortem* examination was performed within two hours after death with the following results. On opening the abdomen the peritoneal cavity was found to contain no fluid, the membranes showed no evidences of inflammatory action, and the exterior surface of the intestines was extremely pale. They were, in fact, of a whitish colour and were closely packed together. The stomach contained undigested food, and the mucous membrane was pinkish and evenly congested over the whole surface. The mucous membrane of the small intestines was congested from the pylorus to the ileo-cœcal valve; it was deep pink and moist; and the villi presented the brush-like aspect previously described in other experiments. The surface was coated with a thick layer of whitish, semi-fluid, flocculent matter, which in many cases completely choked the lumen of the gut on a cross section being made, and which on microscopic examination was found to be entirely composed of cylindrical epithelium, mingled with which were a few bacteria. The epithelial cells were in singularly perfect condition, and were either scattered or in sheets and masses. The large intestine was healthy in appearance. It contained normal fœcal matter, and the mucous membrane showed no

Post-mortem appearances: pale and compact aspect of the intestines;

Congestion and disorganisation of the entire small intestine;

and the lumen of the gut filled with a thick creamy fluid composed almost entirely of cylindrical epithelium.

Congestion of mesenteric glands—the fluid in them contained bacteria.

signs of congestion or other morbid change. The mesenteric glands were of a deep pink hue internally, and contained abundance of fluid of a similar colour. This fluid on microscopic examination was found to be crowded with the cells normally present in such glands, and to contain in addition a large number of active bacteria. The latter subsequently multiplied to a great extent in a preparation which was mounted in a wax-cell.

The liver was very soft in texture, but showed no evidences of the occurrence of embolism. The spleen and kidneys were healthy, and the bladder was full of urine, containing numerous cylindrical epithelial scales and active bacteria.

Thoracic viscera.

On opening the thorax, the pleural cavities were found to contain no fluid, and the membranes were smooth and healthy. The lungs were pale and collapsed. There was no pericarditis. The right cavities of the heart contained dark fluid blood, and the left auricle and ventricle were empty.

Blood from the heart contained a sprinkling of bacteria, which rapidly increased in the wax-cells.

Two preparations of blood were mounted in wax-cells. When examined a few minutes afterwards, one of the specimens was found to contain a sprinkling of minute, active bacteria, whilst in the other only one or two could be detected. Twenty-four hours afterwards, the former specimen was crowded with large active bacteria, which were often arranged in long series and in ramifying flakes. The other preparation also showed a considerable increase in the numbers of bacteria present, although by no means so great as had previously been observed in other similar cases.

Material used (supernatant fluid), about 100 hours old.

EXPERIMENT XX.—A large healthy pariah dog was put under the influence of chloroform at 12 noon of the same day in which the previous operation was performed, and four drachms of the same fluid employed in it were injected into the right femoral vein. The operation was rapidly and successfully accomplished; there was no hæmorrhage, and the animal quickly recovered from the influence of the chloroform, and attempted to make its escape.

Appeared to be very ill at first, but nearly well on the following day.

Shortly afterwards it became dull and depressed, and continued in that condition throughout the rest of the day. At 7 A. M. of the following day it was still somewhat dull looking, but was sitting up and drinking water freely, and at 2 P. M. it appeared to have almost entirely recovered from the effects of the operation, and was made the subject of another experiment (No. LVI) from which it also recovered.

Material used (supernatant fluid), about 100 hours old.

Experiment XXI.—A pariah dog of average size was put under the influence of chloroform immediately after the completion of the previous experiment, and four drachms of the same fluid employed in it was injected into the right femoral vein. The operation was rapidly and in every way successfully performed.

The respiration ceased whilst the wound was being stitched up, but was readily re-established, and the animal quickly recovered from the influence of the chloroform. It passed a normal evacuation soon after the operation was completed, and remained in a somewhat depressed condition throughout the rest of the day. On the following morning, however, it was much livelier, and 24 hours after the operation it appeared to be quite well and was very desirous of effecting its escape, which it succeeded in doing not long afterwards.

Escaped on the second day apparently unaffected.

(*e.*)—*The choleraic matter used being* SIX *days old.*

Material used (supernatant fluid), 144 hours old.

Experiment XXII.—The dog which had previously been employed in Experiment IV was put under chloroform, and half an ounce of the supernatant fluid of the same dejection previously made use of in Experiment XV was injected into the left femoral vein. The dog appeared to be very little affected by the operation. Four days after he was in excellent health; but the wound in the thigh was still open.

No result.

Several preparations of blood were made by opening a cutaneous vein, and either treated with osmic acid and acetate of potash, or without the use of any re-agent; but in neither series could any traces of bacteria be detected.

No bacteria in the blood 4 days after the injection.

(*f.*)—*Choleraic material used being* EIGHT *days old.*

Material injected being the same as in Experiment XXII, but two days older.

Experiment XXIII.—A strong young pariah dog was put under chloroform, and half an ounce of the fluid of the same evacuation employed in the preceding ex-

Death in 3 hours.

periment, injected into the right femoral vein. Owing to the slipping of a ligature, the dog lost about a couple of ounces of blood during the operation. The hæmorrhage was, however, controlled, and the dog recovered from the influence of the chloroform, but died about three hours subsequently.

Post-mortem appearances; —Fluid in peritoneal cavity; intestines lined with a slimy pinkish material.

A *post-mortem* examination was made within six hours after death. The abdomen was considerably distended. There were two or three ounces of reddish fluid in the peritoneal cavity, and the intestines were pinkish externally. They were distended with air, and coated with a slimy, pale pinkish material, but contained very little fluid. The liver was pale, and there were already gaseous bubbles beneath the peritoneal coat.

There was no fluid either in the pleural or pericardial sacs. The lungs were collapsed. The right cavities of the heart were distended with black blood; those of the left side were empty.

(*g*.)—*Choleraic material used being* TEN *days old.*

Material injected 10 days old, crowded with bacteria and granular cells; death in 2½ hours.

EXPERIMENT XXIV.—A healthy, but very young pariah pup was put under chloroform, and about three drachms of the fluid of the same evacuation employed in the previous experiments, but which had now been kept for eleven days, was injected into the right femoral vein. The dog rapidly recovered from the chloroform; but there was some disturbance of the respiration, more especially immediately after the injection. The material injected was crowded with monads and bacteria, and contained numerous circular cells nearly the size of blood corpuscles and with granular contents.

Post-mortem appearances; —nothing special.

The dog died 2½ hours after the operation, and a *post-mortem* examination was performed six hours afterwards. *Rigor mortis* absent. The abdomen was distended, and the peritoneal cavity contained some reddish fluid. The intestines were distended with air, but contained no liquid. The mucous membrane was, in one or two spots, coated with pinkish mucus. The liver and spleen were healthy in aspect.

The lungs were collapsed, airless, and bloodless. Both sides of the heart were distended. Specimens of blood, both from the heart and from the *vena cava inferior*, showed no distinct traces of either monads or bacteria, although carefully examined for them.

Blood, removed from the heart six hours after death, contained no distinct bacteria.

(h.)—Material used being TWELVE *days old.*

EXPERIMENT XXV.—A small pup was put under chloroform, and 2 drachms of the material used in the previous experiment were injected into the right femoral vein. Respiration ceased during the administration of the chloroform, but was re-established after it had been carried on artificially for a few minutes. Towards mid-day the dog died without having shown any choleraic symptoms, but having apparently never recovered from the *shock* of the injection.

Material injected 12 days old. Death in about 4 hours, apparently from 'shock.'

EXPERIMENT XXVI.—A healthy dog was put under chloroform, and nearly half an ounce of a choleraic evacuation which had been passed 12 days previously injected into the median basilic vein. The operation was performed with hardly any loss of blood, and the dog rapidly recovered from the influence of the chloroform.

Material used 12 days old, swarming with bacteria.

It did not appear to suffer from the operation, and on the following day appeared to be in perfect health. The fluid injected was swarming with bacteria and vibriones.

The dog apparently well next day.

(i.)—Choleraic material used being FIFTEEN *days old.*

EXPERIMENT XXVII.—A large healthy pariah dog was put under the influence of chloroform, and half an ounce of choleraic fluid was injected into the right femoral vein.

Material used same as in Experiment XVI to XVIII, but 15 days old.

The fluid was the same as that employed in Experiment XVI, XVII, and XVIII, but had now been kept for 15 days. It retained its intensely fœtid odour, but its re-action was now faintly acid. The animal rapidly recovered from the influence of the chloroform, appeared totally unaffected by the operation, and remained in perfect health for the next three days, when it was made the subject of an experiment on the effects of section of intestinal nerves.

No effect whatever.

EXPERIMENT XXVIII.—A large healthy pariah dog having been put under the influence of chloroform, three drachms of the same fluid employed in the preceding operation which had just been performed, were injected into the left femoral vein.

Material used same as in last experiment, 15 days old.

The dog appeared entirely unaffected by the operation, and remained quite healthy for the next three days, at the close of which period it was killed under the influence of chloroform.

No effect: animal killed under chloroform.

An immediate *post-mortem* examination was made, and the intestines, together with the other thoracic and abdominal viscera, were found to be perfectly healthy in appearance. Some of the mesenteric glands were reserved as in Experiment XI, and were examined after 24 hours. The fluid contained in the interior of them showed an abundance of moving molecular matter, but not a single specimen of the elongated vibriones occurring in the other reserved glands.

Viscera healthy: the glands contained moving molecules, but no vibriones, even after 24 hours.

EXPERIMENT XXIX.—A small pup, similar to those employed in Experiments XXIV and XXV, was put under chloroform, and one drachm of the evacuation employed in Experiment XX, &c., was injected into the right femoral vein. The operation was completed with perfect success and with no hæmorrhage or disturbance of the surrounding tissues. Shortly after the injection respiration ceased but was readily re-established.

Material injected 15 days old.

After the completion of the operation the respiration was considerably disturbed. In the course of an hour or so, the animal began to whine and appeared to be in pain, moving about his limbs and turning on his back. He vomited three or four times and passed one evacuation. He died four hours after the operation, and a *post-mortem* examination was performed 2½ hours after death.

Death in 4 hours.

Rigor mortis was strongly marked. The body was scarcely warm, and the wound was quite healthy. The peritoneal cavity contained no fluid, and the membrane was not injected. The intestines were distended, and, in greater part, of a purplish hue. They contained a pinkish slimy substance, which, as a rule, was most highly coloured

Post-mortem appearances: Intestines congested and lined with pinkish mucus.

opposite the most purplish portions of the intestine. The pinkish tint of the contents did not, in this instance, correspond with the presence of patches of worms, for the latter were in several instances observed to occupy pale portions of the intestine. The liver was healthy; the kidneys were congested.

Blood from the heart contained monads and bacteria.

The pleural cavities contained no fluid. The lungs were collapsed, airless and bloodless. Both sides of the heart were full of blood. The blood contained active monads and distinct bacteria.

(*j.*)—*Choleraic material used being* EIGHTEEN *days old.*

EXPERIMENT XXX.—A very young pup, similar to that employed in the previous experiment, was put under chloroform, and nearly one drachm of the same evacuation, which had now been kept for 18 days, was injected into the right femoral vein. The operation was performed without loss of blood; although respiration ceased, it was readily re-established, the restoration being apparently facilitated by holding the animal up by the heels. There were no symptoms of intestinal affection, but death supervened ten hours subsequent to the operation.

(*k.*)—*Choleraic material being* NINETEEN *days old.*

Injected material 19 days old; the dog well in two days.

EXPERIMENT XXXI.—A healthy dog of average size was put under the influence of chloroform, and four drachms of the same evacuation employed in the previous experiment were injected into the left femoral vein. There was no hæmorrhage, nor were the surrounding tissues disturbed. Towards the close of the operation the respiration became imperfect, but it never fairly ceased, and the animal quickly recovered from the effects of the chloroform. It did not appear to suffer from the operation, and in two days appeared to be in perfect health.

Injected material 19 days old: death in 5 hours.

EXPERIMENT XXXII.—A healthy pup was put under the influence of chloroform, and a few drachms of the supernatant fluid of an evacuation which had remained for 19 days in the laboratory was injected into the right femoral vein. There was hardly any hæmorrhage during the operation, and the dog rapidly recovered from the influence of the chloroform.

It died five hours and a half afterwards, and a *post-mortem* examination was performed three hours after death.

Post-mortem appearances. Sanguineous fluid in small intestines.

Rigor mortis was well marked. The abdomen was slightly swollen and there was a little colourless fluid in the peritoneal cavity. The duodenum was of a pinkish hue internally and contained thick, pale, slimy matter. Further down, the contents of the intestines were watery and of a sanguineous hue. There was pink coloration throughout the jejunum and ileum, but both this and the fluidity of the contents diminished in the neighbourhood of the ileo-cœcal valve. The large intestine was normal in appearance. The liver contained numerous light coloured patches similar to those previously described in the *post-mortem* examination of Experiment XIII. It was not congested. The spleen and kidneys were normal.

The lungs were totally collapsed, airless, and bloodless. The *venæ cavæ*, right auricle, and right ventricle were full of dark and light coagula. The left cavities of the heart contained a little dark coagulum.

(*g*).—*Choleraic material used being* TWENTY-TWO *days old.*

Injected material 22 days old; the animal well in 3 days.

EXPERIMENT XXXIII.—A healthy dog was put under the influence of chloroform and half an ounce of the same choleraic dejection which was employed in Experiments XXIII, &c., and which had now been kept for 22 days was injected into the right femoral vein. The operation was performed with perfect success; the animal rapidly recovered from the influence of the chloroform, did not appear in any way to suffer from the injection, and three days subsequently was in a state of, seemingly, perfect health.

2.—INJECTIONS OF AQUEOUS SOLUTIONS OF CHOLERAIC MATERIAL INTO THE VEINS OF ANIMALS.

(*a*).—*The solutions being recently prepared.*

Equal parts of filtered choleraic dejection and water, recently prepared.

EXPERIMENT XXXIV.—A young pariah pup was put under the influence of chloroform at 8. A. M. and two drachms of a solution of choleraic material were injected into the right femoral vein. The solution had been prepared about half an hour before the operation, and consisted of equal measures of a perfectly fresh and filtered choleraic evacuation, and of water.

No result.

The animal rapidly recovered from the influence of the chloroform, and did not appear to be much affected by the operation. Before evening he was as lively as though nothing had happened to him, and was on the following morning made the subject of Experiment XXXVIII.

A recently diluted solution of choleraic material (96 hours old).

EXPERIMENT XXXV.—The pup which had two days previously been the subject of Experiment V, and which appeared to be in perfect health was put under chloroform, and two drachms of a freshly prepared solution of choleraic evacuation [were injected into the left femoral vein. The solution consisted of the supernatant fluid and a little sediment of an evacuation which had been kept for about 96 hours in the laboratory. The animal rapidly recovered from the influence of the chloroform, was quite fresh and lively shortly afterwards and subsequently made its escape.

No result.

A recently diluted solution of choleraic material 14 days old.

EXPERIMENT XXXVI.—A healthy young pariah dog having been put under the influence of chloroform, half an ounce of an aqueous solution of choleraic material was injected into the right femoral vein. The solution was perfectly fresh, and the evacuation employed had been kept for fourteen days. During the course of the day the dog passed some watery reddish evacuations; but, on the following morning, appeared healthy and continued to do so until the third day, when he was made the subject of Experiment XL.

Passed reddish watery evacuations during the day; the following morning unaffected.

A recently diluted solution of choleraic material 25 days old.

EXPERIMENT XXXVII.—A healthy pariah pup was put under the influence of chloroform, and a freshly prepared solution of choleraic material injected into the right femoral vein. The evacuation employed was that which had afforded the materials for injection in Experiments XIII and XXXII, and had been kept for 25 days at the time the solution was prepared. The proportions of the water and choleraic fluid in the solution were 20 minims of the latter to one ounce of the former.

Results—Diarrhœa; rigors; death in 7½ hours.

The injection was successfully performed and the dog rapidly recovered from the influence of the chloroform; but the respiration continued to be hurried and somewhat irregular for nearly an hour. This symptom, however, passed off, and the dog appeared not very much affected. He refused all food, however, and began to suffer from diarrhœa, passing evacuations, the first of which were normal in aspect, while the subsequent ones became more and more mucous and blood-streaked. Four hours and a half after the operation, he was observed to suffer from rigors, and these continued to occur for the next three hours at the close of which period he died.

Post-mortem appearances.

Small intestines filled with reddish fluid and extremely congested.

No distinct red corpuscles in the fluid, but amorphous particles and epithelial cells.

A *post-mortem* examination was performed two and a half hours after death. *Rigor mortis* had not set in. The body was still slightly warm and the abdomen was not distended. The parts around the wound in the thigh appeared quite healthy, and the vein above the ligature was normal in aspect and distended with fluid blood. On opening the abdomen the cavity was found to be free of fluid, and the peritoneum seemed to be quite healthy. The stomach contained glairy fluid mingled with bile. The interior of the small intestines was extremely congested, and the mucous membrane was of a deep pink colour from the duodenum to the ileo-cœcal valve. They were full of a red fluid mixed with grumous matter. This material when subjected to immediate microscopic examination showed no distinct traces of blood cells, but contained mere amorphous particles with some oil globules and a few epithelial cells. The large intestine was pale and almost empty. The liver was abnormally friable, and showed numerous yellow fatty spots scattered over the surface and extending into the substance. The gall-bladder was full but not distended. The spleen appeared healthy. The medullary portion of the kidneys was very red, while the cortical substance was of a pale yellow tint and fatty aspect.

Thoracic cavity.

On opening the thorax, no signs of pleurisy could be detected. The lungs were totally collapsed, airless, and almost bloodless. The pericardium was healthy, and contained no fluid. The right cavities of the heart were full of dark coagula and fluid blood. The left cavities were empty and the ventricle was strongly contracted.

(*b*).—*The solutions having been prepared* TWENTY-FOUR *hours previously.*

Solution prepared 24 hours previously.

No result.

EXPERIMENT XXXVIII.—The dog which had on the preceding day been made the subject of Experiment XXXIV without appearing in any way affected by it was again put under the influence of chloroform, and two drachms of the solution previously employed, but which was now in an active state of decomposition containing innumerable monads, bacteria and vibriones, were injected into the left femoral vein. The animal recovered quickly, as on the previous occasion, remained well afterwards and was subsequently the subject of Experiment XIV.

Solution prepared 24 hours previously: death in 4 hours.

EXPERIMENT XXXIX.—A young healthy dog was put under chloroform, and half an ounce of an aqueous solution of choleraic material injected into the right basilic vein. The solution had been prepared twenty-four hours previously, and was derived from the same evacuation as employed in Experiment XXX. The operation was successfully performed, and the dog rapidly recovered from the influence of the chloroform. Shortly afterwards well marked rigors occurred, and the animal died four hours subsequently having passed one liquid evacuation during the interval.

Post-mortem appearances: injection of small intestine.

A *post-mortem* examination was performed one hour and three quarters after death. The body was still warm, and *rigor mortis* just commencing. The peritoneal cavity contained no fluid and the membrane was healthy. The mucous coat of the intestines both large and small was injected almost universally, but the contents of the guts were of a yellowish-white tint, only here and there showing a pinkish tinge. In these coloured portions the consistence of the mucous matter of which they were composed was more fluid than elsewhere. Several tortuous patches of small vessels were visible on the surface of the liver; they were gorged with blood, but the hepatic cells in their neighbourhood appeared to be unaffected in any way when examined microscopically. The spleen and kidneys were healthy.

No monads nor bacteria in the blood, nor did they develop, during the next 2 days, when fungi appeared, the covering glasses having been cracked.

On opening the thorax the pleural cavities were found to be quite healthy. The lungs were collapsed, airless and bloodless, and several dark extravasated patches were present in each. The heart was healthy. The right cavities were full, and the left almost empty. Specimens of blood were obtained from each side of the heart, but no distinct traces of monads or bacteria could be detected in them at the time, nor were any observed to have developed in them two days subsequently, when filaments of fungi had crept into the preparations through cracks in the covers of the wax-cells in which they were contained.

(*c.*)—*The solution having been prepared* FORTY-EIGHT *hours previously.*

Solution prepared 48 hours previously.

EXPERIMENT XL.—The dog employed in Experiment XXXVI, but which now appeared to be in perfect health, and with the wound in the right foreleg clean and healing, was again put under the influence of chloroform, and five drachms of the solution used in the preceding experiment, but which had now been kept for 48 hours, was injected into the left median vein. The fluid was thoroughly shaken up previous to injection, in spite of which the animal rapidly recovered from the influence of the chloroform, and began to run about as though nothing had happened. He continued in apparent good health during the next two days, and was then made the subject of Experiment VI.

No result.

3.—INJECTIONS OF ORGANIC SOLUTIONS, OTHER THAN OF CHOLERAIC NATURE INTO THE VEINS OF ANIMALS.

Organic substances, not choleraic, injected into the veins.

The arrangement adopted in the preceding sections will be followed out in this also, so that comparisons between the various classes of experiments may be more readily made. The introductory remarks which have been made concerning them, apply equally to this, the conditions under which they were conducted being the same; the animals were taken indiscriminately, irrespective of sex, age or strength, the solutions for injection having usually been prepared before the animals had been seen.

The veins of the neck not suitable for these experiments.

It will be seen that the femoral and brachial veins have been selected in preference to the veins of the neck, owing to the complications which we had, in early attempts, frequently observed to have followed the occurrence of even slight cellulitis in that region.

(*a.*)—*The injecting material used whilst fresh.*

Material injected: fresh, diluted and filtered blood (fowl's).

EXPERIMENT XLI.—A small quantity of recently drawn fowl's blood was shaken up with about its equal weight of water, and filtered: half an ounce of this filtered mixture was then injected into the right femoral vein of a young dog four months old, whilst under the influence of chloroform.

No result.

In a short time the animal recovered from the effects of the anæsthetic, and soon partook of food. Slight lameness alone indicated that anything had occurred, and on the third day he appeared quite well, when he was subjected to a repetition of the experiment (*vide* Exp. XLIX). There were no traces of blood corpuscles in the filtered solution used for injecting.

Material injected: diluted but not filtered solution of fresh blood (fowl's).

EXPERIMENT XLII.—Some freshly-drawn fowl's blood was prepared, as in the foregoing, but not filtered, so that coagula and corpuscles were sucked up into the syringe, it having been ascertained that corpuscles, as well as coagula, were retained when an attempt was made to strain off the latter through tow. The nozzle was introduced as before into the femoral vein of a powerful dog, and three fluid drachms injected into it.

No result; no evidence of embolism detected at the post-mortem examination.

The dog after recovering from the chloroform did not appear to be much affected by the operation, and three days afterwards looked so well that he was again placed on the table in order to introduce some putrefying blood, but respiration suddenly stopped, and could not be re-established. The internal organs were perfectly healthy, not the slightest evidence of embolism being manifested.

Material injected: a strained solution of recently passed fœcal matter: the dog had three days previously been injected with putrefying solution of blood.

EXPERIMENT XLIII.—Three drachms of a watery solution of recently passed healthy fœcal matter, which had been five times filtered through muslin (so as to get rid of any large particles which might have been floating in the mixture), were injected into the left femoral vein of a dog, into whose right femoral vein some putrefying blood had been injected three days previously without any very marked result, although he was evidently far from well (*vide* Exp. LIII).

No result: animal escaped.

The dog quickly recovered from the effects of the chloroform, took to his food readily, and by the third day was so far improved as to have managed to make his escape.

Material injected: fresh peritonitic fluid.

EXPERIMENT XLIV.—Half an ounce of perfectly fresh sanguineous peritonitic fluid was injected into the right femoral vein of a large, healthy pariah dog which had been previously placed under chloroform. The fluid had been obtained from the peritoneum of a dog in whom peritonitis had been produced by the introduction of a solution of normal evacuation into the abdominal cavity (*vide* Exp. LXXIV).

Recovery in 3 days.

Post-mortem examination: every organ healthy.

The animal continued somewhat dull and sluggish throughout the day: the following day it was more lively, but a large inflamed swelling had appeared around the seat of the incision. On the fourth day it was very much improved and seemed to have nearly recovered. On the fifth day it was again put under chloroform, which was pushed until respiration ceased. A *post-mortem* examination was immediately made, but not the slightest sign of peritonitis nor of embolism could be traced, the only lesion observed being the inflammatory condition of the wound in the thigh. The bladder was full of urine, and the mucous membrane of the intestines perfectly healthy.

(*b.*)—*The organic solution injected being* ONE *day old.*

Material injected, diluted ordinary fœcal matter 24 hours old: death in 3 hours.

EXPERIMENT XLV.—A healthy young puppy was put under chloroform at 8 A.M., and three drachms of a fluid composed of mixture of water, and healthy fœcal matter which had been prepared twenty-four hours previously, were injected into the right femoral vein. The dog recovered perfectly from the effects of the anæsthetic, but died at 11 A. M. of the same day, three hours after the operation, having passed several mucous stools in the interval, although the first stool passed after the operation presented no such appearance.

Post-mortem examination.

A *post-mortem* examination was made at 4 P. M. of the same day, and we found that the peritoneal cavity contained reddish serous fluid. The peritoneum was not injected, and there were no signs of inflammation of the membrane. The stomach was empty, containing only about an ounce of glairy fluid, its mucous coat healthy. The duodenum was deeply congested and contained thick yellowish mucus.

Marked congestion of intestines, with fluid resembling that found in cholera.

The congested surface, when wiped, resembled the hairs of a hair pencil when flattened out. In the jejunum the fluid was more watery and closely resembled that found in the intestines in cholera cases. In the lower part of the ileum there was less congestion of the mucous membrane, the contents here were fœcal and not fluid, and towards the ileo-coecal valve the surface was quite pale. The large intestine was pink and contained pinkish mucus.

No other special change.

There was a yellow patch at the edge of one of the lobes of the liver in which the minute vessels of the part presented a prominent tortuous appearance, evidently due to small local congestions. The spleen was large and showed numerous soft milky nodules on section. The kidneys were normal, not congested. The lungs healthy, collapsed and scarcely crepitant; the right cavities of the heart were full, the left empty.

Materials used: a strained solution of ordinary fœcal matter, 24 hours old.

EXPERIMENT XLVI.—A little ordinary fœcal matter was diluted with about twice its weight of water, allowed to stand for twenty hours, and afterwards twice strained through three layers of muslin. The solution was then injected into the left femoral vein of a young dog whilst under the influence of chloroform. During the operation, the respiratory movements suddenly ceased, but were re-established after artificial respiration had been persevered in for nearly ten minutes.

Death in 29 hours after passing pinkish stools.

The animal seemed to be quite comfortable during the day, but at night he became sluggish, passed reddish, liquid stools, and died on the following day, twenty-nine hours after the operation.

Post-mortem appearances: prune-juice like exudation in intestines, and pneumonic patches in the lungs.

The body was examined an hour and a half after death. There were no signs of peritonitis. The stomach was empty, the duodenum contained yellowish, bile-stained, fluid, and both small and large intestines contained a considerable amount of a grumous substance of the consistency and colour of blackcurrant jam or prune-juice, evidently due to altered blood exudation. The liver was extremely fatty. Kidneys and spleen normal. The heart was healthy, the cavities on both sides empty. There were numerous pneumonic patches interspersed throughout the lungs, but no indication of further mischief.

Material injected ; a solution of ordinary fœcal matter, 24 hours old : no result.

EXPERIMENT XLVII.—The dog used in Experiment LIX having quite recovered was put under chloroform again, and six drachms of a solution of normal evacuation, prepared 24 hours previously, were injected into the left femoral vein. The animal did not seem to be the least affected by this operation neither until the next day, when it became sickly, and still more so on the second day, when chloroform was again administered, and a *post-mortem* examination at once made.

All the viscera healthy.

There was no fluid in the peritoneum, nor the least trace of peritonitis; the intestinal mucous membrane appeared to be perfectly healthy and pale, so were the mesenteric glands, and all the other abdominal and thoracic organs.

The blood contained bacteria.

A wax-cell preparation of the blood from the vena cava was made, and examined the next morning, when a scanty sprinkling of active bacteria were seen to be present; and on the third day the preparation was crowded with stiff short bacteroid bodies, perfectly still and resembling crystals.

Material injected ; solution of ordinary alvine discharge, 34 hours old; no effect.

EXPERIMENT XLVIII.—A very powerful pariah dog was put under chloroform, and six drachms of fluid which had been employed in the preceding experiment, ten hours previously, were injected into the right femoral vein.

The animal quickly recovered, and was under observation for three days, but not the slightest indications of functional disturbance were manifested, and it was subjected to another operation (*vide* Experiment LXII).

(*c.*)—*The organic material injected being* TWO *days old.*

Materials used : decomposing solution of blood 48 hours old, filtered.

EXPERIMENT XLIX.—A small quantity of the solution of blood which had remained over since its employment in Experiment XLII of this series, and which was found to be in an advanced state of decomposition, swarming with bacteria, was filtered as before, so that all solid particles together with the bacteria were got rid of, and afterwards injected into a branch of the left femoral vein of the same dog, into whose right femoral vein the fresh filtered solution had previously been injected, without ill effects (*vide* Experiment XLI).

No effect whatever.

The animal was under observation for four days, was in no way affected, eating freely any food that was placed before him.

Material used; a solution of ordinary fœcal matter, 48 hours old: death, almost immediate.

Experiment L.—Four drachms of a decomposing solution of ordinary fœcal matter were injected into the right femoral vein of a medium-sized dog. No blood was lost; and, but very little chloroform used, still the animal almost immediately after the operation began to breathe in an intermittent manner, gasped several times and died.

Cause of death could not be ascertained; bacteria in the blood of both sides of the heart.

The body was examined immediately, in order to ascertain whether the bacteria which the solution contained, had passed through the lungs into the left side of the heart. Specimens of blood were, therefore, carefully removed from the right and from the left cavities, and on microscopic examination, we found numerous very energetic bacteria in all the specimens. The preparations of blood from the right side of the heart appeared to contain more bacteria than those from the left. All the organs were healthy, no indications existing of the cause of the sudden death.

Injection of a solution of ordinary fœcal matter, 48 hours old.

Experiment LI.—A large healthy pariah dog was put under chloroform as usual, and six drachms of the solution of ordinary alvine discharge used in Experiment XLVII, but now forty-eight hours old, were injected into the left femoral vein. The ligature commanding the lower end of the vein unfortunately slipped, and considerable hæmorrhage ensued. It was, however, ultimately secured, and when the animal awoke it ran away.

Death in about 20 hours. Disorganisation of mucous membrane of small intestine.

Having been re-caught, it was kept under observation during the day, but nothing special was noted. During the night, however, the animal died and a *post-mortem* examination was made next morning. The intestines were filled with a soft pinkish substance, consisting chiefly of epithelium, and the mucous surface of the small intestine generally was much disorganised. The other abdominal and thoracic organs were healthy.

Material injected same as in Experiment LI; 96 hours old, swarming with bacteria. Death from shock in a few minutes.

Experiment LII.—Immediately on completion of the preceding experiment, another huge pariah dog was put under chloroform, and six drachms of the same decomposing fluid, swarming with bacteria, injected into its right femoral vein. The animal ceased to respire almost immediately, and efforts to restore it were in vain, although it had nearly come from under the influence of the anæsthetic, and none had been administered for some time.

Post-mortem appearances.

The viscera were forthwith exposed; the right side of the heart was enormously distended, and the left contained a little blood. The mesenteric glands were pink and contained red blood-corpuscles. The liver was of a very dark colour and gorged with blood; other viscera healthy.

Bacteria developed in preparations of blood from all parts of the circulation.

Three wax-cell preparations of the blood were made; one from the right side of the heart, another from the left side, and a third from the *left* femoral. Of these, in the first only could active bacteria be distinguished when examined immediately after the specimens were prepared; nor did any appear in the other two for some hours; next morning, however, all three contained an abundance of moving bacteria.

And in the juice of axillary and mesenteric glands.

Two wax-cell preparations were also made of the fluid squeezed out of an axillary, and out of a mesenteric gland, both of which contained numerous active bacteria, and monads from the first, and their numbers increased greatly during the following twenty-four hours. In about four days the activity of the monads and bacteria ceased, motionless molecules alone remaining in the blood, as well as in the gland-juice preparations.

(*d.*)—*The organic material injected being* THREE *days old.*

Material used; two drachms of putrid blood-solution, 72 hours old; crowded with vibriones.

Experiment LIII.—In order to complete the series of filtered and unfiltered, fresh, and decomposed solutions of a simple organic liquid, two drachms of the decomposed watery solution of fowl's blood, which had been used in previous experiments, and had, by this time, acquired an intensely putrid odour, and swarmed with active bacteria, were injected, without previous filtration, into the right femoral vein.

Owing to various accidents the dog had to be kept under the influence of chloroform for a considerable time. Its respiration twice entirely ceased, and was, on each occasion, restored by mechanical means. At the close of the operation the abdomen was extremely distended.

No effect.

In spite of these adverse circumstances, the animal on the second day was quite lively, and partook of its food freely, although the wound did not present a healthy appearance; but on the fifth day it was so far recovered as to be considered fit to undergo another operation, from which he also recovered and eventually escaped (*vide* Experiment XLIII).

Material used; a solution of ordinary fœcal matter, 72 hours old: death almost immediate.

EXPERIMENT LIV.—Half an ounce of the watery solution of ordinary fœcal matter which had been used in Experiment L and which now emitted an extremely fœtid odour, was injected into the femoral vein of a small young dog, but within a few minutes after the operation, although he appeared to be getting out of the influence of the chloroform, his breathing altered and was carried on by gasps. An attempt was made to draw off blood from the opposite femoral vein; but the circulation had stopped.

Post-mortem appearances; nothing special; bacteria in the blood of the right side of heart but none in axillary vein.

The viscera were at once exposed, but nothing distinctly abnormal observed. The venous system was intensely gorged with blood and both sides of the heart were distended. In the blood abstracted from the cavities of the right side, monads and bacteria were detected, but in blood removed from the axillary vein no positive evidence could be obtained of the presence of bacteria; the injected fluid would of course have had to pass through the capillaries of the lungs and of the systemic circulation before reaching the axillary vein.

Material used; solution of ordinary fœcal matter about 72 hours old: the animal already twice injected.

EXPERIMENT LV.—A small pariah dog into whose femoral veins two different specimens of decomposing choleraic dejecta had already been injected without producing any marked result, was again placed under chloroform and half an ounce of the decomposing solution of ordinary fœcal matter (exactly as used in the last experiment (LIV), both experiments being performed on the same day) was injected into the median basilic vein.

No result; killed under chloroform after a week.

After the operation, it is noted, "the dog appears as if nothing had happened." He was kept under observation for a week, when, in order to ascertain what changes all these putrefying matters might have produced, he was again placed under chloroform, and allowed to breathe it till respiration ceased. The wounds over two of the three veins which had been tied were completely healed. There was no peritonitis, the intestines were pale and perfectly healthy, so were all the viscera except the lungs and spleen. In the former, on both sides, large patches of hepatized tissue were found evidently due to pneumonia, and, enclosed by this altered tissue, at one spot was a small cavity filled with a dark thickish fluid. In the spleen there was, near the surface of one end, a small extravasated pouch about the size of a hazel-nut.

Hepatised tissue in both lungs; a cavity in one; extravasated spot in the spleen. No bacteria in the blood.

The blood was carefully examined for monads and bacteria, but none could be found.

Material used; solution of alvine discharge, 72 hours old: no effect.

Experiment LVI.—Half an ounce of a decomposing solution of ordinary alvine discharge, 72 hours old, the same as used in Experiment XLVII, &c., was injected into the right femoral vein of a dog, previously brought under the influence of chloroform. Not a drop of blood was lost during the operation.

There were not the slightest manifestations of illness during the three days the animal was kept under observation, and when the viscera were examined after it had been killed under chloroform, they were all found to be perfectly healthy.

Bacteria not developed in the blood, nor in the glands.

A wax-cell preparation of the blood was kept under observation for three days, but no bacteria nor any other organisms developed. A similar preparation was made by squeezing some fluid out of a mesenteric gland; here also no monads or bacteria could be detected during the period above named.

Material injected, solution of ordinary alvine discharge, 72 hours old. Animal previously experimented upon: no effect.

Experiment LVII.—The subject of Experiment XX, a large pariah dog, into whose right femoral vein decomposing choleraic fluid had been introduced five days previously without producing serious illness, was put again under the influence of chloroform, and six drachms of a solution of normal fœcal matter injected into the other femoral vein. Neither was the animal much affected by this, and four days afterwards appeared to be in perfect health, when it was killed under chloroform and immediately examined.

No bacteria developed in the blood, but they did in the gland-fluid as well as long vibriones.

The thoracic and abdominal viscera were normal, and the mucous coat of the intestines quite unaffected. A wax-cell preparation of blood from the heart appeared to be a perfectly healthy sample; there were no bacteria visible, nor were any developed during the following two days. A similar preparation was made of the fluid in the mesenteric glands (which was very abundant); on the first day no distinct bacteria were visible, but on the following morning the preparation was crowded with very active large bacteria, together with long, active, and still oscillatoria-like vibriones, such as are depicted in fig. 1, page 34; on the third day these organisms were all motionless and degenerated into a beaded leptothrix network (fig. 2, page 34).

(*e.*)—*The injected material being* four *days old.*

Material used, healthy alvine solution, 96 hours old.

Experiment LVIII.—A large healthy pariah dog was brought under the influence of chloroform, and four drachms of a solution of healthy alvine discharge, which had been prepared 96 hours previously, were injected into its right femoral vein. The dog rapidly recovered, and seemed to be but little affected.

Mucous dejections mixed with cholera-like flocculi.

Presently, it appeared to become drowsy, and in the course of half an hour symptoms of great irritation of the bowels were manifested. The animal was evidently much griped, and passed several mucous stools mixed with blood. This it continued to do during the day, numerous gelatinous flocculi also being mixed with the dejections. The flocculi when subjected to microscopic examination consisted of exudation cells (similar to those occurring in the flocculi of cholera dejecta), together with a few epithelial cells and structureless gelatinous material.

Death in 13¼ hours. Pink coating to the mucous membrane of small intestine, beneath which the epithelium was unaffected.

Thirteen hours after the operation the dog died, and a *post-mortem* examination was made immediately. No fluid in peritoneum, no evidence of peritonitis; mesenteric glands much enlarged: dark pink internally and containing fluid of a similar colour. The small intestines were very pale externally, whereas the mucous surface was of a dark pink colour, being coated with a reddish mucous substance, which on removal showed the epithelial coat unaffected, and the mucous membrane not congested. No further evidence of morbid change could be discovered.

Material injected, alvine solution, 96 hours old: no effect.

Experiment LIX.—Four drachms of the alvine solution, 96 hours old, as used in the last experiment, were injected into the right femoral vein of a moderate sized dog under chloroform. The dog continued to be very active for some time, and attempted to make its escape, and was evidently by no means so much affected as the previous animal. By the next day it appeared to be quite well, and some more decomposing material was introduced into its circulation without producing any effect (*vide* Exp. XLVII).

Material injected, normal alvine solution, 96 hours old: no effect.

Experiment LX.—A large healthy dog placed under chloroform, and four drachms of the solution used in the two previous experiments were introduced into the right femoral vein. There was no loss of blood. It continued drowsy for a considerable time, but recovered during the course of the day, and by the fifth day was so far recovered as to seem fit to undergo another operation (*vide* Exp. LXIII).

Material injected, normal alvine solution, 96 hours old: death in a few hours.

Experiment LXI.—A small healthy pariah dog was put under chloroform, and five drachms of the solution of ordinary fœcal matter used in Exp. LVII, &c., now 96 hours old, were injected into the right femoral vein very successfully. The animal died within a few hours, and a *post-mortem* examination was made.

There was slight injection of the diaphragmatic pleura close to the pericardium, otherwise there were no indications of disease. The intestines were perfectly healthy.

Wax-cell preparations of blood from the heart and of fluid from the mesenteric glands were under observation for four days. The blood specimen continued perfectly free from all moving particles whatever, and contained no distinct motionless bacteria; whereas the gland-juice preparation was swarming with bacteria on the second day.

Bacteria did not develope in the blood, but did in the gland-fluid.

Experiment LXII.—As the dog used in Experiment XLVIII appeared to be vigorous and in excellent health, he was again put under chloroform, and six drachms of the same fluid as was used on the previous occasion, but now farther advanced in decomposition, being 96 hours old, were injected into the left femoral vein; on the third day he appeared to be perfectly well again, and when examined after being killed under chloroform, all the organs, including the intestines, appeared to be in a healthy condition.

Material injected, ordinary alvine solution, 96 hours old: no result.

A wax-cell preparation of the blood and another of fluid derived from the mesenteric glands were kept under observation for three days, but no moving bodies of any kind, monads or bacteria, were seen from first to last.

No bacteria developed in blood or gland-fluid preparations.

Experiment LXIII.—The powerful dog used in Experiment LX looked so well on the following day, as to be considered fit to undergo another operation, consequently having been brought under the influence of chloroform, six drachms of the solution of fœcal matter used in Experiment LVII, now 96 hours old, were injected into the remaining femoral vein.

Material used 96 hours old: no result.

The animal very quickly recovered from this also, and on the third day was killed in order to note the condition of the viscera. No lesion whatever could be found.

A drop of blood was carefully removed from the right external iliac vein and placed in a wax-cell, and a drop of fluid from the interior of a mesenteric gland was similarly enclosed for observation. During the three days that they were thus watched, not a single distinct monad nor bacterium was seen in either of the specimens.

No bacteria developed in blood or gland preparations.

Material used, a solution of ordinary alvine discharge, 100 hours old : no effect.

EXPERIMENT LXIV.—A large pariah dog was placed under chloroform, and an ounce of the same solution as used in Experiment LVIII, &c., a hundred hours old, was injected into the right femoral vein. It continued drowsy for some time, vomited a large quantity of bilious matter, and by the next day was tolerably well. The wound, however, had assumed an unhealthy, sloughy appearance, so the animal was killed forthwith. There was no peritonitis, the intestines were normal in every way, so were all the other viscera, thoracic and abdominal. The bladder was full.

No bacteria developed in the blood.

A wax-cell preparation of a drop of blood removed from the external iliac vein of the unwounded side, and a similar preparation of fluid pressed out of a mesenteric gland, were kept under observation for three days, during which period neither monads nor bacteria were seen in the former, but an abundance of white cells, whereas in the latter a few bacteria eventually appeared.

Material used same as in last experiment: death in 2½ hours.

EXPERIMENT LXV.—A large healthy pariah dog was placed under chloroform; and five drachms of precisely the same fluid as used in the last experiment were injected into its left femoral vein. After the operation it seemed to be much depressed, and vomited several times. The animal continued in this condition for two-and-a-half hours, when it died.

Congestion of villi and detachment of epithelium.

A *post-mortem* examination was immediately made, and it was found that the small intestines, though very pale externally, were internally deeply congested, and the lumen of the gut choked with a semi-fluid slimy substance, consisting chiefly of detached epithelium, the individual cells being in a perfect state of preservation. Beneath this substance the villi were seen to be deeply congested, presenting a brush-like appearance. The stomach was healthy, and so was the large intestine. The mesenteric glands looked healthy, and so did the remainder of the abdominal viscera. There was no peritonitis nor pleuritis, but there seemed to be some slight pericarditis. The lungs were collapsed and pale, and both sides of the heart contained fluid blood.

(*f.*)—*The injected material being* FIVE *days old.*

Material used, solution of fœcal matter 120 hours old: no effect.

EXPERIMENT LXVI.—A powerful pariah dog was placed under chloroform, and half-a-ounce of the decomposing solution of fœcal matter used in Experiment LIV, &c., was injected into the right median-basilic vein. During the operation the animal on two occasions ceased to breathe, but was each time speedily brought round by artificial respiration.

On the following day the dog appeared to be perfectly well, and made his escape.

(*g.*)—*The injecting material being* SEVEN *days old.*

EXPERIMENT LXVII.—The dog referred to in the last experiment was caught towards the evening of the day on which he made his escape, and on the following morning placed under chloroform, when six drachms of the same fluid as had already been introduced into its circulation, but now two days older, which had since remained in an uncorked bottle, and was swarming with bacteria and vibriones, were injected into the other median-basilic vein.

During the four succeeding days the animal was closely watched, but he appeared to have been in no way affected.

Post-mortem: all organs healthy. No bacteria in the blood, nor did any develop in a week.

Having been killed under chloroform, the viscera were carefully examined, but no lesion detected anywhere, nor were there any signs of deposit in the lungs, liver or other organs. Three preparations of blood were obtained from a thoracic vein, and examined immediately, but not a single bacterium could be detected, nor were there any developed in the cells, although under observation for a week.

B.—Experiments on the Introduction of Choleraic and of other Organic solutions into the Peritoneal cavity of animals.

Reasons for undertaking the series of experiments recorded in this section.

When the series of experiments on the effects of the introduction of solutions of alvine discharges directly into the circulation, as recorded in the previous pages, had been carried on for some time, we debated whether we should at once proceed to repeat similar experiments with solutions of various other organic and of inorganic substances, of acid, alkaline or neutral re-actions, or whether we should continue to use the same infecting medium, varying the mode by which its introduction into the system was effected.

Having satisfied ourselves that putrefying matter introduced directly in the blood, did very frequently exert as direct an action on the mucous membrane of the small intestine, as for example, mercury exerts on the mucous lining of the mouth and on the salivary glands, or as atropia and calabar bean exert on the iris, we yet felt convinced that the physiological phenomena evoked, and the pathological changes induced, were not those of cholera, although appearing to present a certain though, distant, relation to them.

Although, some remedial agents act in pretty much the same way, no matter how introduced into the system, whether by the mouth, lungs or through the skin, such as mercury and turpentine, the former increasing the salivary secretion, and the latter the urinary, still, their actions are to some extent modified by the mode of administration. We were, therefore, anxious, in the first place, to ascertain whether the introduction of precisely the same media, through some other channel, would modify their action on the system, in such a way as to bring the results to approximate more closely to the features presented in cholera, and in the second, whether the effects produced by one kind of alvine discharge could, in any way, be distinguished from those of another.

With these ends in view we conducted the following series of experiments on the effects of the introduction of organic fluids into the peritoneal cavity.*

An ounce of choleraic material, about 100 hours old, injected into the abdominal cavity of a dog.

EXPERIMENT LXVIII.—A large, healthy pariah dog was put under the influence of chloroform at 8-30 A. M., and one ounce of choleraic evacuation in a state of decomposition (having been kept for 96 hours) was injected into the peritoneal cavity. Previous to injection a preparation of the blood was mounted in a wax-cell; shortly after the operation the animal was observed to suffer from well marked rigors, which recurred at intervals throughout the course of the day.

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* The results of introduction of such materials into the system through the mucous membrane of the lungs will be made the subject of experiment shortly.

Result: extreme depression, but no evidence of pain, nor of cramps.

It remained in a state of extreme depression, lying in a semi-drowsy condition, and neither whining nor showing any other symptom of pain or uneasiness. A close watch was kept on the symptoms throughout the whole day, but nothing new presented itself; there was no passage of urine, nor of dejecta, and the only change observed was a gradual increase in the depression and drowsiness. Towards evening the animal appeared to be rapidly becoming weaker and could not stand on its legs, but the limbs were quite lax and showed not the slightest evidence of cramps. It seemed to suffer from thirst, and drank water freely when offered to it.

Killed under chloroform.

As it appeared to be very improbable that life would be prolonged until the following morning, chloroform was again administered at 7 P. M. and continued until respiration had ceased. A *post-mortem* examination was then performed immediately with the following results.

Post-mortem appearance: sanguineous fluid in peritoneum containing myriads of very active amœboid bioplasts.

On opening the abdomen the cavity was found to be distended with sanguineous fluid. This fluid was subjected to careful microscopic examination. It contained a few red blood-corpuscles and myriads of very active amœboid bioplasts, which in many cases, until their movements and changes of form were observed, presented a curiously marked resemblance to cylindrical epithelial cells. Many others, however, were ragged in outline, and passed off into long thread-like extensions. The fluid surrounding the cells was very clear, hardly any molecular matter could be detected in it, and only here and there was a minute tremulous monad to be seen.

But only very few monads.

Peritoneum injected.

The peritoneum and mesentery were intensely injected and thickened, but there was no distinct evidence of the presence of solid exudative flakes between the viscera.

Small intestines coated with, what seemed to be, inspissated blood, which could be peeled off, leaving the mucous surface perfectly healthy.

The stomach contained about ten ounces of glairy fluid, its mucous surface appeared to be perfectly healthy, there were no points of extravasation present, and the vessels were not injected. The duodenum also appeared to be healthy and contained some bilious fluid. The mucous membrane of the jejunum was coated with a dark layer of what appeared to be inspissated blood. This layer became more and more marked lower down, and attained its maximum development in the ileum, where it was of the consistence of treacle and of a dark tarry colour. This dark layer could be pealed off the surface of the mucous membrane, leaving the latter dry, but otherwise quite healthy in appearance. The tarry coating ceased abruptly about a foot above the ileo-cœcal valve and was replaced by one composed of the common, whitish, gelatinous mucus normally lining the intestines in dogs. The mucous membrane here also appeared quite healthy, and there was neither extravasation nor any evidences of detachment of epithelium present. The walls of the lower extremity of the ileum and those of the appendix vermiformis were considerably thickened. The large intestine appeared healthy internally.

This coating ceased about a foot above the ileo-cœcal valve.

No extravasation, but much thickening of the mucous membrane.

The tarry and pale mucous coatings on the interior of the small intestine, together with the subjacent layers of the mucous membrane, were subjected to careful microscopic examination. The tarry layer consisted of a gelatinous, molecular, more or less fibrillated basis identical in appearance with that of the normal flakes of intestinal mucus. In, and on this, were innumerable blood-crystals, a few indistinct bioplastic masses and various particles of intestinal contents together with large numbers of ova. Not a single red blood-corpuscle was visible in spite of the extreme profusion of blood-crystals, and the distinct sanguineous hue, that even the thinnest layers, into which the material could be spread out, retained. The whitish grey coating, replacing the former one at the lower end of the ileum, was identical in appearance and structure with it, minus the red colour and the abundant blood-crystals, and was, in reality, what it appeared to be at first sight, namely, the normal thick mucus of the gut.

Microscopical appearance of intestinal exudation.

Absence of red blood-corpuscles, but a profusion of blood-crystals.

The material scraped from the mucous surfaces beneath these layers consisted entirely of distinct cylindrical epithelial cells and of detached villi, many of which showed their epithelial coating firmly and evenly attached, even, after the violence to which they had been subjected.

The subjacent layer when scraped consisted of normal epithelial cells, and villi.

There was not the slightest resemblance between the microscopic characters of this layer and those of the superincumbent one, whether the latter were of normal

Not the slightest resemblance between the microscopical elements of the exudative and mucous layers.

aspect as at the lower end of the ileum, or deeply blood-stained and tarry as further up.

Remaining abdominal viscera healthy.

The liver was dark in colour and very full of blood, but no farther change could be detected in it. The remaining abdominal organs were congested, but no special lesion could be detected in any of them. The bladder was full of urine.

Thoracic viscera healthy.

On opening the thorax, the pleural cavities were found to be free from fluid. The lungs were collapsed and healthy in texture. The heart was healthy, the right cavities full, but not distended with fluid blood, and the left auricle and ventricle empty.

Wax-cell preparations of blood from the heart were set aside and when examined on the following day, were crowded with pus-like corpuscles, but neither, monads nor bacteria could be seen nor did they subsequently appear.

A preparation of blood from the right side of the heart was mounted in a wax-cell and set aside for further examination, along with the preparation procured previous to the operation. Both preparations were examined on the following morning at 9 A. M., when the one had been kept for above 24 and the other for about 14 hours. On examination the former was found to be quite free from bacteria, and to contain very abundant bioplasts in the pus-like condition previously alluded to, whilst the latter only differed from it in there being rather fewer bioplasts free in the serum. They were again carefully examined two days subsequently. They both remained very fluid in consistence, very few bioplasts were present in a distinctly defined condition, they were aggregated in masses, and appeared to be rapidly undergoing disintegration. Neither bacteria nor active molecules could be anywhere detected in either preparation. On subsequent examination the only changes observed in either specimen were gradual disintegration and there was no development of bacteria in them.

An ounce of choleraic material—about 100 hours old, injected into peritoneal cavity of a dog.

EXPERIMENT LXIX.—At 12 noon of the same day in which the preceding experiment was performed, chloroform was administered to another large healthy pariah dog, and about one ounce of the same choleraic material was injected into the peritoneal cavity through a canula. The dog soon recovered from the primary effects of the operation, and was not affected by such distinctly marked rigors as the former animal had been.

Result: depression; neither cramps nor purging.

His general demeanour, however, was precisely similar to that observed as the result of the other operation; he was profoundly depressed, lying perfectly quiet and neither whining nor showing any other indication of pain. Neither fœces nor urine were passed throughout the whole day, and there were no evidences of spasm of any of the muscles. As he appeared fully less depressed than the other dog, it was decided to allow him the chance of surviving until the next morning, and his condition at that time had not materially altered, the only change perceptible being an apparent increase in the depression.

Killed under chloroform.

Chloroform was, accordingly, again administered at 7-30 A. M., 19½ hours after the operation, and the administration carried on until respiration ceased.

Post-mortem appearances.

Peritonitis, with sanguineous fluid in the cavity.

The abdomen was opened before complete cessation of respiration and circulation. The cavity was distended with fluid of a somewhat less marked sanguineous hue than that present in the previous experiment, but, otherwise, it presented the same characters both to the unaided eye and when subjected to microscopic examination. The peritoneum, both visceral and parietal, presented well marked signs of inflammation, and the vessels on the intestines were highly injected and very red.

Shreds of exudation over the liver, crowded with corpuscles, identical in appearance with those found in cholera-dejections.

There were a few shreds of soft lymph diffused over the surface of the liver, which, on microscopic examination, were found to consist of aggregations of more or less spherical corpuscles, identical in appearance, and probably also in nature with those present in such abundance in the fluid after the active, vital, amœboid movements had ceased. The resemblance of such shreds of soft lymph to the flocculi contained in choleraic evacuations, cannot fail to strike any observer even at the first glance.

The small intestines coated with a dark sanguineous substance, and contained tarry fluid, except

The mucous membrane of the stomach was healthy. The duodenum was also normal in aspect, and contained a little bile. The jejunum and ileum presented precisely the same phenomena as those present in the previous case, but to an even more marked degree, as, for a few inches above ileo-cœcal valve.

towards the middle of the ileum, the cavity of the gut contained tarry fluid in addition to the sanguineous coating of the mucous membrane. Towards the lower extremity of the ileum the walls of the intestine appeared to be considerably thickened. For a few inches above the ileo-cœcal valve the tarry coating was absent, and was replaced by a layer of the normal thick intestinal mucus.

Mucous coat not affected.

Specimens of these layers, and of the mucous membrane beneath them, were, in this instance also, carefully examined under the microscope, and their nature was found to be precisely similar. Here also the effusion had taken place without impairing the integrity of the epithelial coat of the mucous membrane in the slightest degree, the latter presenting a remarkably dry and firm aspect when the exudative layer was peeled off from it, and it was most remarkable to observe the very small number of epithelial cells which adhered to the latter in spite of the violence involved in the separation.

Large intestine not distinctly affected.

The large intestine contained a larger quantity of dark coloured fluid than was present in the previous case, but the gut was not affected in any way equally with the small intestine.

The rest of the abdominal organs were congested, but showed no other lesions of any kind.

The bladder was full.

Wax-cell preparation of blood presented numerous leucocytes after a few hours, but no bacteria.

The heart was healthy in appearance. A specimen of blood from the right ventricle was mounted in a wax-cell. When examined, eight hours after preparation, it was found to contain a considerable number of leucocytes, some of which were of large size, whilst others were still exhibiting amœboid movements. No distinct evidences of the presence of bacteria could be detected, although they were especially searched for with a ⅛th immersion lens, nor did any appearances of the development of such bodies present themselves during the next four days, whilst the preparation was kept under observation.

Choleraic material seven days old, injected into the abdominal cavity.

EXPERIMENT LXX.—A large healthy pariah dog was put under the influence of chloroform at 11-30 A. M., and one ounce of a watery solution of the sediment of the choleraic evacuation employed in the two preceding experiments, and which had now been kept for seven days, was injected into the peritoneal cavity.

No result.

Killed under chloroform, 24 hours after operation.

The animal appeared to be very little affected by the operation, had no rigors after it, showed no symptoms of pain, and in the afternoon ran home along with the servant, who had the charge of the dogs to his hut in a village, about half a mile off. On the following morning he was brought back, and at this time also appeared in no way affected by the operation. Chloroform was administered until respiration ceased, and a *post-mortem* examination was then immediately performed, nearly 24 hours after the injection had taken place.

Post-mortem appearances; very slight peritonitis; viscera healthy.

On opening the abdomen about three ounces of pinkish-grey fluid were found in the peritoneal cavity. The mesentery was thickened and injected, and there were a few small patches of soft lymph on the liver. The walls of the intestines appeared to be slightly thickened, but they were otherwise normal in appearance. The bladder was distended with fluid. The rest of the abdominal and thoracic viscera appeared to be quite healthy.

Half an ounce of a solution of ordinary fœcal matter, three days old, injected into the abdominal cavity.

EXPERIMENT LXXI.—A strong, healthy pariah dog was put under the influence of chloroform at 8 A. M., and half an ounce of a solution of a normal evacuation was injected into the peritoneal cavity. The solution had been prepared three days previously, and was in an active state of decomposition.

Death in about 15 hours.

The dog was kept under close observation for seven hours, during which it showed no marked symptoms of any kind, and then went home with the man in charge, walking along with him without manifesting any symptoms of pain or inconvenience. The man brought its body next morning and stated that, soon after he took it to his house, it suffered from severe rigors, and that it died about eight hours afterwards without having shown any other decided symptoms.

There was no vomiting, and no evacuations were passed subsequent to the operation. A *post-mortem* examination was performed eight hours after the occurrence of death.

Post-mortem appearances.

Reddish fluid in peritoneal cavity, containing a few red blood corpuscles, and numerous pus-like cells, with bacteria and vibriones.

On opening the abdomen, extensive signs of peritonitis presented themselves. The cavity contained an abundance of fluid of a reddish tint and somewhat thick consistence. When subjected to microscopic examination, it was found to contain a few red blood-corpuscles, and very numerous granular pyoid cells of a more or less circular form. They were all perfectly motionless, seemingly dead, and the fluid surrounding them was crowded with active bacteria and vibriones.

Tarry coating of small intestines, except for a few inches above ileo-cœcal valve.

The interior of the small intestines presented the appearances previously described in Experiments LXVIII and LXIX. There was a continuous coating of a dark tarry aspect beneath which the epithelial surface appeared quite healthy. As before, about six inches of the ileum, immediately above the ileo-cœcal valve, was unaffected. The large intestine also was covered with a coating of tarry material.

No other noteworthy lesion was to be found in any of the abdominal or thoracic organs. There was no pleurisy.

Blood from the heart contained a few bacteria.

Specimens of blood from the right ventricle were found to contain a few bacteria, when subjected to careful examination under a $\frac{1}{12}$th immersion lens.

Six drachms of beef solution, 96 hours old, very putrid, injected into the peritoneal cavity.

EXPERIMENT LXXII.—An extremely powerful pariah dog was, with much difficulty, brought under the influence of chloroform at 8 A.M., and about six drachms of a decomposing solution of beef was injected into the peritoneal cavity. The solution had been prepared ninety-six hours previously, and at the time of the injection was of an intensely fetid odour and swarming with active bacteria and short vibriones.

No special symptoms; killed under chloroform 24 hours after operation.

The dog was somewhat dull and depressed throughout the course of the day, but on the following morning he did not appear to have become any worse, and was still so strong, as to give much trouble whilst chloroform was again administered until the cessation of respiration.

Post-mortem appearances: fluid in peritoneum swarming with amœboid bodies, but at first

A *post-mortem* examination was then performed at once, 24 hours after the injection of the fluid had taken place. On opening the abdomen the cavity was found to contain about two ounces of red serous fluid almost resembling pure blood in appearance. A preparation of this fluid was mounted in a wax-cell and examined one hour afterwards. It was then found to contain numerous red blood-corpuscles and myriads of active amœboid bioplasts, but no bacteria could be detected in it although they were specially searched for under a $\frac{1}{8}$th immersion lens.

no bacteria, which however were plentiful next day.

On the following day, however, there were plenty of active bacteria present. The red corpuscles remained unchanged; but the bioplasts had lost all amœboid motion, had assumed a more or less spherical form, and were in process of disintegration. By the following morning the activity of the bacteria had ceased, and shortly afterwards the preparation dried up.

Intestines contained tarry sanguineous effusion; other viscera healthy.

The intestines were congested externally, and their internal surface presented patches of the tarry sanguineous effusion described as occurring in the preceding Experiments Nos. LXVIII, LXIX, &c. The appendix vermiformis was of very large size, but appeared to be quite healthy. The rest of the abdominal and thoracic viscera appeared not to be affected in any way, and the bladder was full of urine.

No bacteria appeared in a wax-cell preparation of the blood.

A specimen of blood from the right ventricle was mounted in a wax-cell and examined an hour afterwards. No monads or bacteria could be detected in it, but an abundance of delicate, active white corpuscles were present. The preparation was kept under observation for some days, but there was no indication of the development of bacteria in it.

Four drachms of fresh peritoneal fluid injected into the abdominal cavity.

EXPERIMENT LXXIII.—A healthy pariah dog was put under the influence of chloroform, and four drachms of the fluid from the peritoneal cavity of the dog of Experiment No. LXXII were injected into the abdomen. The fluid had been obtained at the *post-mortem* examination in the above experiment, which was performed immediately before the injection took place.

Death in about 12 hours.

The animal rapidly recovered from the influence of the chloroform, and appeared to be little affected by the operation. It remained quiet during the day, showing no symptoms of pain, or of cramps, but it vomited once or twice. Death occurred during the early part of the night, and a *post-mortem* examination was performed on the following morning.

Post-mortem appearances; fluid in peritoneum

crowded with bacteria and small pus-like corpuscles, which contained active molecules.

On opening the abdomen, the peritoneum was found to be extremely congested, and the cavity contained a considerable amount of sero-sanguinolent fluid. A preparation of this fluid was mounted in a wax-cell as usual and examined about an hour afterwards. It was then found to be swarming with very active bacteria, and to contain a few red blood-corpuscles, together with numerous small pyoid corpuscles in a state of disintegration. When again examined, after the lapse of a few hours, the bacteria were observed in unimpaired activity, and the breaking up of the pyoid corpuscles appeared to be progressing rapidly, many of them containing from one to three granular rings or Nuclei in their interior; whilst in many such cells the molecules between the rings or Nuclei and the outer pellicle were in active swarming motion.

On the following day almost all the corpuscles had disappeared or had become uniformly granular, and the movements of the bacteria had become more sluggish. The preparation was kept under observation for several days; but the only further changes observed to take place in it were a progressive disintegration of the granular corpuscles and a gradual diminution in the activity of the bacteria.

Intestines coated with a prune-juice-like substance.

Pericardium injected and contained reddish fluid.

The intestines were coated internally with a sanguineous layer of a deep prune-juice colour. The rest of the abdominal viscera appeared to be unaffected. On opening the thorax, there was found to be no pleurisy; the pleural cavities contained no fluid, and the lungs were quite healthy. The pericardium was injected and contained reddish serous fluid. The heart was normal.

In a wax-cell preparation of blood, no bacteria were detected at first, but small vibriones gradually appeared;

A preparation of blood from the right ventricle was mounted, as usual, in a wax-cell. When examined, about an hour afterwards, nothing abnormal was detected in it. After the lapse of a few hours, the preparation was again examined. Crystals had begun to form along the margin; there was only a narrow ring of free serum, and very few white corpuscles were visible. At first no monads or bacteria could be detected; but a rapid development of very delicate vibriones took place, whilst the preparation was under observation. They were elongated, of extreme tenuity and of great activity. On the following day the serum was swarming with the bodies described above. They remained very active, and their delicacy was so great as to necessitate most careful management of the light, in order to render them visible. No further development occurred; and the only changes subsequently observed were gradual diminution in the activity of the vibriones together with breaking up of the small number of white cells present in the serum.

but the light required careful adjustment, in order to see them.

An ounce of fresh peritoneal fluid injected into the abdominal cavity.

EXPERIMENT LXXIV.—Whilst the *post-mortem* examination described in the previous experiment was being performed, a syringe was filled with the fluid contained in the peritoneal cavity, and another powerful pariah having been subjected to the influence of chloroform, about one ounce of this fluid was injected into the abdomen. During the operation, respiration and circulation ceased for a short time, but they were easily re-established, and the dog rapidly recovered from the influence of the chloroform. At first, it appeared to be very little affected by the injection; but it rapidly passed into a state of extreme depression, and died five hours after the operation.

Death in 5 hours.

Post-mortem appearances: peritonitis very marked;

A *post-mortem* examination was performed two hours after death, with the following results. *Rigor mortis* had just begun to set in, but the tissues were still warm. On opening the abdomen, there was found to be very marked peritonitis. There was a large quantity of red fluid in the abdominal cavity.

blood contained active bacteria, small disintegrating pus-like corpuscles and oil-globules.

When a preparation of this fluid mounted in a wax-cell, was examined an hour after its removal from the body, it was found to be crowded with minute, slightly moving bacteria and monads, and to contain masses of very small disintegrating pyoid corpuscles, together with numerous free oil-globules. The preparation was kept under observation for several days; but no further developments occurred, and the activity of the bacteria gradually ceased. The intestines were rough and injected externally; but, when

Intestines coated with a prune-juice-like substance.

laid open, they did not show nearly so much of the prune-juice exudation as had been observed in other previous instances. The condition of the mucous surface as regarded exudation closely corresponded with that observed in the case of the dog, into the peritoneal cavity of which decomposing beef-juice had been injected (*vide* Experiment LXXII). The rest of the abdominal organs appeared to be quite healthy.

Thoracic viscera: injected appearance of pericardium.

Blood full of minute active particles.

On opening the thorax, there was found to be well marked injection of the pericardium, especially on its external surface; but the pleuræ lungs and heart were unaffected. A preparation of blood from the right ventricle was examined an hour afterwards, and was found to be full of very minute active particles. No farther development of these bodies was detected during the subsequent few days in which the preparation was preserved.

A solution of normal evacuation, six hours old, injected into the abdominal cavity.

EXPERIMENT LXXV.—Chloroform having been administered to a strong healthy pariah dog, an ounce of a decomposing solution of normal evacuation was injected into the peritoneal cavity. The solution employed had been kept for six hours in a wide-necked bottle which was loosely plugged with cotton-wool, in order to keep flies and other insects out.

The animal rapidly recovered from the influence of the chloroform and showed no symptoms of pain or of cramps, but after some time it passed some bloody mucous evacuations.

After passing mucous stools, it was killed under chloroform, 14 hours after operation.

Post-mortem appearances: intense peritonitis; fluid in peritoneum crowded with granular corpuscles:

It was killed with chloroform fourteen hours after the injection, and a *post mortem* examination was performed at once. On opening the abdomen, the peritoneum was found to be intensely inflamed and thickened, and flakes of soft lymph were adhering to the liver and other viscera. The cavity contained about a pint of sanguineous fluid. A preparation of this fluid in a wax-cell was examined two hours subsequent to its removal from the abdomen; it was found to consist of a clear fluid crowded with bodies resembling the white corpuscles of the blood, and containing numerous red blood-corpuscles also. More than half of the white cells were stil actively emitting long stringy protrusions. There were numerous delicate filbrinoid threads

Bacteria developed in the course of a few hours.

netted through the preparation, but although a careful search was made for them with the ⅛th immersion lens, neither bacteria nor vibriones could be anywhere discovered in it. Three hours afterwards, however, a few motionless bacteroid bodies were observed in it, and twenty-four hours after, a few moving bacteria were present, and the field was covered with elongated motionless vibriones (Leptothrix ?).

Except immediately above the ileo-cœcal valve, the intestine was coated with tarry substance consisting of

Mucus, blood-crystals, white granular cells, but no red corpuscles nor epithelial cells.

When the small intestines were laid open, the ileum immediately above the ileo-cœcal valve was found to present a perfectly normal aspect, but throughout the rest of the gut the mucous membrane was coated with a tarry layer similar to that observed and described in several previous cases. As before, this was found on microscopic examination to consist of the normal tough intestinal mucus crowded with blood-crystals and containing a few white granular cells, but entirely devoid of red blood-corpuscles and epithelial cells. There was no detachment of epithelium, and on peeling off the bloody, mucous layer, the epithelial coat was exposed quite intact and merely characterised by a certain dryness of appearance. The large intestine was unaffected, and the rest of the abdominal organs appeared to be healthy. The bladder was full of urine.

Pericardium injected with deposits of lymph on its surface.

On opening the thorax the lungs and pleuræ were found to be perfectly healthy, but the pericardium was injected, and there were deposits of lymph on its surface. The heart did not present any abnormal appearances.

At first no monads were visible, but they developed during the day.

A preparation of blood from the heart was, as usual, mounted in a wax-cell. When examined, an hour afterwards, no traces of monads or bacteria could be detected in it. Three hours subsequently it was again examined, and one or two moving molecules, together with some still ones, were then detected, whilst very few white corpuscles had crawled out into the serum. On the following day there was an abundance of active bacteria in the serum; they continued in motion throughout that day, but had all become still when the preparation was again examined on the subsequent morning.

An ounce of peritonitic fluid, 36 hours old, injected into the abdominal cavity.

Experiment LXXVI.—A very powerful pariah dog was put under the influence of chloroform, and one ounce of the peritonitic fluid obtained from the abdominal cavity of the dog of Experiment LXXII, and which had been previously employed in Experiment LXXIII, was injected into the peritoneal cavity. This fluid had been kept in an open gallipot for thirty-six hours at the time when the injection was performed.

No marked effect.

The dog rapidly recovered from the influence of the chloroform, and remained somewhat dull and sluggish throughout the course of evening. It did not, however, show any symptoms of pain or cramps, and on the following morning, about fifteen hours after the injection, it did not appear to be any worse.

Killed under chloroform, 15 hours after operation.

Post-mortem appearances: peritonitis; the fluid contained active bacteria and active ragged bioplasts.

It was accordingly killed with chloroform, and a *post-mortem* examination was performed at once. The appearances which presented themselves did not differ materially from those described in connection with the preceding experiments. Preparations of the peritoneal fluid and of the blood were, as usual, mounted in wax-cells. The peritoneal fluid was examined an hour after its removal from the body, and was then found to contain an abundance of minute active bacteria. There were also numerous bioplasts and red blood-corpuscles, the former of irregular shape, and showing slow changes in form only. Three hours afterwards the bacteria continued in activity, the bioplasts were very ragged in outline, and there were now numerous groups of delicate, beaded, motionless threads resembling leptothrix, present. On the following day these threads had disappeared, and the preparation was crowded with bacteria and monads, some of which were motionless, whilst others were in full activity.

The blood contained a few active bacteria.

The preparation of the blood was also examined an hour after it had been set up. It then showed no distinct bacteria, but contained numerous minute, motionless molecules. It was again examined after an interval of three hours, and a few active molecules, together with two very active short vibriones, were observed in the serous ring. Only two or three white cells had crept out. A second preparation, however, at this time contained an abundance of free white cells, and showed neither active molecules nor bacteria. On the following day the former preparation showed some patches of still molecules: the latter now contained a few active bacteria. No farther developments occurred in either of these preparations subsequently.

Half an ounce of fresh peritonitic fluid injected into the abdominal cavity.

No marked effect; killed under chloroform 48 hours after operation.

EXPERIMENT LXXVII.—A healthy pariah dog was put under the influence of chloroform at 8-30 A. M., and half an ounce of peritonitic fluid which had immediately before been removed from the abdominal cavity of the dog of Experiment LXXV was injected into the abdomen. The animal appeared to be somewhat dull and depressed for a short time, but in the afternoon it seemed to have entirely recovered from the effects of the operation. It continued in apparent health throughout the following day, and was killed with chloroform on the next morning, 48 hours after the injection.

No peritonitis; all the organs healthy.

A *post-mortem* examination was performed at once, but no lesions could be detected. There was no peritonitis, and all the organs were quite healthy in aspect.

An ounce of a solution of healthy evacuation injected into the abdominal cavity.

EXPERIMENT LXXVIII.—A large healthy pariah dog was put under the influence of chloroform, and an ounce of the supernatant fluid of a solution of healthy evacuation was injected into the peritoneal cavity. The solution was that employed in Experiment LXXV, and was at the time of injection 72 hours old. It had been retained as before in a wide-necked bottle plugged loosely with cotton-wool.

No marked effect: 24 hours after operation the dog was again put under chloroform and the abdomen opened; marked peritonitis evident.

The dog was dull and depressed during the day, but drank water freely in the evening, and on the following morning, 24 hours after the operation, it appeared to be perfectly well. It was, accordingly, again put under chloroform and the abdominal cavity opened. There was considerable inflammation of the parietal peritoneum, the mesentery and intestines were intensely injected and inflamed, but there was no fluid present.

A loop of gut ligatured, filled with water, and returned into the abdomen; and chloroform continued for an hour, when the animal was killed.

A loop of the small intestine was ligatured, the ligatured portion filled with tepid water, by means of a pointed syringe introduced through the walls, and the gut returned to the abdomen which was then sewn up. The administration of chloroform was then continued and the animal died under its influence after an hour.

Post-mortem appearances: intense congestion of intestines, except the ligatured loop, which was macerated and covered with a layer of loose epithelium.

A *post-mortem* examination was performed about half an hour after death. The interior surface of the small intestines with the exception of the ligatured loop was intensely congested, the latter portion had lost all traces of congestion, presented a macerated appearance, and was covered with a layer of soft pale loose epithelium. No other changes observed.

An ounce of fresh choleraic evacuation injected into the abdominal cavity.

EXPERIMENT LXXIX.—A healthy pariah dog was put under the influence of chloroform, and one ounce of a choleraic evacuation, which had been passed by a patient in hospital a few minutes previously, was injected into the peritoneal cavity. The fluid employed was the same as that used in Experiment I of the series of injections into the veins, and the two operationswere performed at the same time.

No result. Killed 24 hours after operation.

The animal appeared to be very little affected by the operation, continued in the same condition throughout the course of the day, and on the following morning, 24 hours after the injection, seemed to be quite well.

Placed under chloroform 24 hours after operation and the abdomen opened; there was intense peritonitis; the watery fluid in peritoneum full of exudation-cells and bacteria.

It was, accordingly, again put under the influence of chloroform and the abdominal cavity opened. It contained an abundance of yellowish watery fluid, which, on microscopic examination, was found to be full of exudation-cells and perfectly free from bacteria. The parietal peritoneum was densely injected and showed distinct evidences of healing peritonitis.

The preparation was reserved in a moist chamber and at the close of 24 hours showed an abundance of active bacteria.

The small intestine was deeply congested. A loop of it having been ligatured, a solution of salt and water was injected into the ligatured portion. The intestine was then returned and the abdomen closed.

The administration of chloroform was continued, and the animal killed at the close of an hour. The ligatured loop of intestine was found to be full of fluid, no absorption appearing to have occurred. The interior surface was coated with white gelatinous matter, and flocculi of a similar nature were floating in the fluid.

A loop of the small intestine was ligatured, salt and water injected, then returned into the abdomen.

Chloroform having been continued for an hour, the loop was examined, but no absorption had taken place.

These flocculi were found, on microscopic examination, to be mainly composed of epithelium, and, when the gelatinous coating was scraped off, the mucous membrane beneath it was found to be deeply congested. The rest of the intestine was intensely congested, and showed patches of the prune-juice coating so characteristic of the mucous membrane of the gut in peritonitis induced by the injection of fluids into the abdominal cavity.

The interior of this portion was lined with a gelatinous substance, chiefly composed of epithelium, and when this was scraped off

the surface below was deeply congested; so was the remainder of the intestine, which was lined with the prune-juice coating.

C.—A short review of the preceding experiments.

In attempting a short analysis of the preceding series of experiments, it will perhaps be as good an arrangement as any to adhere to the classification already adopted in their narration.

1. Thirty-three experiments have been described, more or less in detail, in connection with the introduction of small quantities of the alvine discharges of cholera patients, unmodified by any admixture, into the veins of dogs of various size and age; whereas seven others are given in which the choleraic injecting material had been diluted with water. Thirty-two dogs were made use of in carrying out these series of thirty-three experiments, one dog having been resorted to on two occasions for the same purpose; whereas some of the others had either already been operated upon, or were so in another class of experiments subsequently undertaken.

The number of animals into whose veins cholera fluid had been introduced.

In these thirty-two experiments sixteen deaths occurred: thirteen evidently from the direct action of the putrefying material exert-

The rate of mortality, about 43 per cent.

ed through or upon the blood; two apparently from shock, and one dog was killed owing to erysipelatous inflammation of a severe kind attacking the wound. These are consequently left out of the calculation. The mortality, therefore, resulting from the direct introduction of choleraic dejections in quantities varying from two to six drachms may be set down as amounting to about 43 per cent.

A Table showing the number of experiments with undiluted choleraic material, the mortality, and the principal lesions produced by its introduction into the veins of dogs.

Age of choleraic material injected.	Number of Experiments.	Number of Recoveries.	Number of Deaths.	Number in which the *intestines* were affected.	Number in which the *pericardium* was affected.	Number in which *embolism* was detected.	REMARKS.
Quite recent ...	1	...	1	...	...	1	
One day	2	2	...	1	...	...	Erysipelas attacked the wound.
Two days ...	3	3	...	...	...	...	
Three " ...	4	1	3	3	1	...	
Four " ...	11	5	6	7	2	2	
Six " ...	1	1	...	...	...	...	Pleurisy present in one.
Eight " ...	1	...	1	1	...	...	
Ten " ...	1	...	1	...	...	...	
Twelve " ...	2	1	1	...	...	...	Death from shock.
Fifteen " ...	3	2	1	1	...	...	" " "
Eighteen " ...	1	...	1	...	...	...	
Nineteen " ...	2	1	1	1	...	...	
Twenty-two days ...	1	1	...	...	...	...	
TOTAL ...	33	17	16	14	3	3	

We much regret that the experiments on perfectly fresh choleraic material are not more numerous, a defect which we trust to remedy very shortly. The difficulty has been to procure a suitable animal when an opportunity occurred for resorting to the experiment—to obtain a dog as it is to obtain anything else at the moment wanted being proverbially uncertain.

Mortality when the material injected was from 1 to 3 days old, and

With this material, one and two days old, five experiments were performed, but all the dogs recovered; whereas when the material used had been kept for three days, three out of four dogs experimented upon died within from three to six hours, and with well-marked lesions in each of them which will be referred to further on. It so happens that in all four of these experiments the same material was used; it was obtained from a questionable case of cholera, and was by no means so offensive to the smell as is generally the case with choleraic dejecta after being kept so long.

from 4 days old; also from 6 to 20 days old.

There are eleven cases recorded in which the choleraic material injected was four days old; of these, six died, or about 54 per cent. In one of the animals which did not die, but was slaughtered, it was found that well-marked intestinal lesions existed. Twelve experiments are likewise cited in which the material used varied from six to twenty-two days old. Four of the dogs died from causes reasonably attributable to the poisonous action of the material introduced, whereas two (puppies) died of shock.

Mortality when diluted choleraic material was introduced, 37 per cent.

2. Of the seven cases in which the choleraic material injected into the veins had been more or less diluted with water, two died, which will be equal to about 35 per cent., this being considerably lower than the mortality when the undiluted material was resorted to. The *post-mortem* appearances were precisely analogous in both instances, but these will be referred to more at length hereafter.

Mortality when solution of ordinary fœcal matter was introduced, 33 per cent.

3. There were twenty-one experiments on the introduction of solutions of ordinary alvine discharges carried out; nine of the animals died, three of these deaths we attribute to shock, which for the sake of uniformity we also leave out of the calculation, thus leaving six deaths, or a mortality a little over 33 per cent., about 2 per cent. less than the mortality from the injection of the diluted choleraic material.

A Table showing the number of experiments with solutions of normal alvine discharges, the mortality, and the principal lesions induced by their introduction into the veins of dogs.

Age of alvine solutions injected.	Number of Experiments.	Number of Recoveries.	Number of Deaths.	Number in which the *intestines* were affected.	Number in which the *pericardium* was affected.	Number in which the *embolism* was detected.	REMARKS.
One day	4	2	2	2	...	...	2 died from shock.
Two days	3	...	3	1	...	...	1 „ „
Three „	4	3	1	...	...	1	Pleurisy occurred in one.
Four „	8	5	3	2	...	...	
Five „	1	1	...	...	...	...	
Seven „	1	1	...	...	...	...	
TOTAL ...	21	12	9	5	...	1	

Result of the injection of other organic solutions.

Four experiments are cited in which solution of fowl's blood, filtered and unfiltered, fresh and decomposed, had been introduced into the circulation without producing the slightest result; and one rather remarkable case is given in which fluid obtained from the abdominal cavity of a dog, in whom extreme peritonitis had recently been induced, and which might be supposed to be highly noxious, produced no appreciable effect; all the organs when examined twenty-four hours after the operation were perfectly healthy.

The frequent occurrence of intestinal lesions.

In carefully looking over the account of the *post-mortem* lesions which occurred in the three preceding classes of experiments, we are struck with the almost constant presence of intestinal complications, varying from more or less intense congestion of the villi and intestinal glands to complete disorganisation of the greater portion of the mucous membrane of the small intestine, its epithelial lining becoming completely detached.

Portions of intestine affected.

With respect to the portion of intestine thus affected, it will be observed that the lesions have been limited to the small intestine

Exemption of the portion near ileo-cœcal valve.

and, in the generality of cases to its whole course from the duodenum downwards, except for a distance of from one to two feet above the ileo-cœcal valve, a portion which in almost every instance has escaped being materially affected. We are totally unable to account for the cause of this exemption, and have tried in vain to reconcile the phenomenon with any known anatomical peculiarities of this part of the gut. We were the more surprised, as we had previously observed at the autopsies of cholera patients—a subject which we, however, for the present postpone—that it was just this very portion which seemed to show the most marked tendency towards the congestions which every now and then are observed to be present in this disease. Future observation may modify this impression, but we venture to go out of our way a little in order to draw attention to it. In no instance was any tendency to special affection of the intestinal glands observed. The stomach and the large intestine have in nearly all the cases seemed to us to be quite healthy.

The oscillatoria-like vibriones in the intestines.

Resemblance between these cases and those of *mycosis intestinalis.*

In connection with these observations on the disorganisation which the small intestine is subject to, when putrefying matters are injected into the blood, it may be remarked that on three occasions we observed a great number of vibriones or oscillatoria-like filaments, embedded in the mucus which lined the intestine after the substance which was free and filling the lumen of the gut had been wiped away. These may have existed in more numerous instances, and been overlooked; still it may seem strange that they all three occurred in dogs into whose veins the dejection from a very mild or even questionable case of cholera, above referred to, as having proved so fatal had been injected. We have deemed these occurrences as worthy of attention, more especially when taken in connection with the cases of mycosis intestinalis, which, we understand, are prominently alluded to by Professor Parkes in his Annual Review of Hygiene in the recently issued Report of the Army Medical Department, which has however not yet reached Calcutta. We shall certainly continue to watch closely for any organisms of the kind in the intestinal canal of man and of animals. It will be seen that similar actively moving vibriones were detected in the mesenteric glands, but not in the blood.

Exceptional cases of resistance to the effects of putrefying substances observed.

Whilst tabulating the results of the experiments recorded, we were somewhat surprised to observe that when a dog had once recovered from the effects of an operation, succeeding operations had not, in a single instance, proved fatal to it, no matter whether the material introduced into its veins consisted of choleraic or non-choleraic, or of alternate doses of these. One of these animals, a healthy but by no means a very large dog, was subjected to four experiments, a vein in each limb having been injected and tied, without result; another was made use of on three occasions in a similar way, and ten on two occasions, all recovering perfectly. This appears to us to argue very strongly in favour of a predisposition, on the part of animals at all events, to be affected by septic influences.

No marked preponderance of cases of embolism.

There were comparatively very few instances in which it could be distinctly noted that marked embolism had occurred; not more than six in sixty-seven experiments. All the dogs, however, were not killed and examined, consequently secondary diseases may have become developed in them afterwards.

Number of experiments, and nature of fluid introduced into the peritoneal cavity.

4. We have recorded twelve experiments on the effect of injecting the peritoneal cavity with solutions of organic materials of a similar nature to those adopted in the experiments just referred to. Four consisted of choleraic material, three of ordinary alvine discharge, one of a decomposing solution of beef, and four of peritonitic fluid recent and decomposed. Deaths only occurred in three cases, namely, two after the introduction of fluid which had just been obtained from the peritoneal cavity of another dog, and one after the introduction of a solution of decomposing ordinary alvine discharge, the remainder were all killed within twenty-four hours of the operation, and all, whether they died or were killed, presented the same marked lesion at the autopsy, with two exceptions—one, a dog into whose peritoneum an ounce of fresh peritonitic fluid had been injected without producing any special symptom during life or any lesion evident after death; the other a case in which the injected material consisted of a solution of choleraic discharge.

A Table showing the number of experiments in which decomposing organic solutions were introduced into the peritoneal cavity, the mortality, and the principal lesions produced.

Nature of solution introduced.	Number of Experiments.	Number of Deaths.	Number killed within 24 or 48 hours.	Number in which the *peritoneum* was affected.	Number in which the *pericardium* was affected.	Number in which the *pleura* was affected.	Number in which the *intestines* were affected.
Decomposing beef-tea ...	1	...	1	...	...	...	1
Peritonitic fluid ...	4	2	2	3	2	...	3
Choleraic dejection ...	4	...	4	4	...	...	3
Normal " ...	3	1	2	3	1	...	3
TOTAL ...	12	3	9	10	3	...	10

The intestinal lesion produced materially different in this series of experiments.

As in the previous series of experiments with decomposing organic solutions, so in this, the most prominent and constant *post-mortem* phenomenon observed was the affection of the mucous surface of the small intestines. The lesion, however, appeared to us to be of a very different nature; in fact, the mucous membrane itself was not in a single instance materially affected, but a sanguineous exudation had taken place giving the tube of the gut a more or less evenly distributed coating, which, when carefully peeled off with a forceps, left the mucous surface and its epithelial lining intact. This matter was on each occasion very carefully looked into; and the substance exuded, as well as the base upon which it was spread, were subjected to careful microscopic examination. The former consisted, almost entirely, of altered blood elements, blood-crystals, &c., but no entire red corpuscle could be detected, whereas the mucus-surface over which it was spread consisted of the unaltered structures belonging to the part.

Result of filling isolated loops of congested intestine with fluid.

In two cases in which the intestines were particularly congested, a loop of the gut was tied whilst the animal was still alive but under chloroform, and luke-warm water injected into the ligatured portion in one case, and salt-and-water in the other, the gut in both cases being returned into the abdomen, and chloroform being continued for an hour. When subsequently examined it was found that no absorption had taken place, but the fluid had so macerated the mucous membrane, that the epithelium had become detached, and floated in flakes in the fluid which had been introduced, and in one of the cases the sub-jacent mucous membrane had lost all appearance of congestion, whereas it was found to have retained it in the other. In the non-isolated portions of the mucous surface, the small intestine in both instances was intensely injected, otherwise the structure of the membrane was intact.

It may be remarked that in this series of experiments also, a portion of the intestine for a short distance above the ileo-cœcal valve was not materially affected.

Association of pericarditis with peritonitis, but not with pleuritis.

In connection with this series it is also to be noted that *Pericarditis*, more or less distinct, was observed in fully one-half of the cases; that portion of the pericardial sac in immediate connection with the diaphragm was the part usually affected, together with the portion immediately attached to the sternum. Perhaps the origin of this may be explained by one of the series of *Observations on the Anatomy of Serous Membranes*, lately published by Drs. Burdon Sanderson and Klein, which shows that when various colouring matters are introduced into the abdominal cavity, the lymphatic vascular system of the diaphragm becomes completely injected, as *also*, *the sternal vessels and sternal glands.*

Intimate connection of the observation with the Lactic acid theory of Rheumatism.

The production of *Pericarditis* but without the co-incident occurrence of pleurisy, by the injection of various putrefying substances into the peritoneum, is especially worthy of note, seeing that the opinion is strongly held by many, that, as Lactic acid, when injected in a similar way (as was demonstrated by Dr. B. W. Richardson), produces inflammation of the serous membrane of the heart, this acid must in some way be connected with the phenomena observed in Rheumatism if not in reality its cause. It seems to us that putrefying substances may, on the same grounds, lay claim to a somewhat similar relationship.

Microscopical appearance of the peritonitic fluid.

With respect to the nature of the fluid produced by the inflammation which had been brought on by the various organic solutions described, it may be observed that under the microscope no difference whatever could be detected between the fluids, beyond that in some cases red blood-corpuscles formed a more prominent feature than in others, but this increased ratio was by no means confined to any particular class of the organic solutions which had been introduced into the abdominal cavity. In the fresh condition this fluid swarmed with irregular masses of bioplasm exhibiting great activity, and very rapidly undergoing the process of segmentation.

When the fluid produced in the peritoneal cavity was transferred to the abdomen of another dog, the bioplastic bodies in the resulting exudation appeared to us to have become smaller and less active; this statement, however, we make reservedly.

Relation existing between the development of bacteria and the activity of the inflammatory process.

With regard to the numbers of bacteria present in this fluid, a fluid by the way, resulting from the introduction of solutions generally teeming with such organisms, we are convinced that no material increase takes place so long as the inflammatory process is progressing actively. It will be observed, on reference to the experiments bearing on this matter, that in several instances not a single bacterium could be detected in the recent fluid, and that in all, the numbers present appeared to bear an inverse ratio to the number and activity of the bioplasts.

The bearing of these experiments on the symptoms and lesions in cholera.

It will be seen that this series of experiments also, failed to induce lesions or phenomena identical in nature with those of cholera; nay more, the affections of the intestine here present, appeared rather to be the result of local disturbance of the circulation excited by the inflammatory action induced by the introduction of extraneous matter into the peritoneal cavity than of the action of any specific agent; in this series likewise, no special action appeared to be excited by choleraic as contrasted with other material. Taken together, the entire series of these preliminary experiments has not afforded any evidence in favour of the existence of a specific poison contained in choleraic excreta, peculiar to them alone, and giving rise to special phenomena when introduced into the system. The number of our experiments do not appear to us to warrant any definite conclusion regarding a difference *in degree* in toxic influence between the two classes of materials; they merely indicate the absence of any special action peculiar to one and absent in the other when introduced into the system by special channels.

Their practical bearing on sanitation.

It must, however, be evident at first sight that the results obtained from these experiments, have a most important practical bearing on sanitation, seeing that they point most distinctly to the influence of decomposing organic matters in the production of intestinal disease; and show, moreover, that this influence may exist in a most potent form without its presence being in any degree proportionally indicated by the amount of fœtor associated with it.

PART III.

EXPERIMENTS ON THE SECTION OF THE SPLANCHNIC AND MESENTERIC NERVES.

Points of difference between lesions in experiments and those of cholera considered with a view to future modification.

When we had satisfied ourselves that decomposing organic matters introduced into the circulation exerted the special if not specific actions previously described, on the intestinal mucous membrane, but an action producing lesions materially differing from those characteristic of cholera, we were naturally led to consider the principal points of dissimilarity with a view to ascertain whether future experiments might not be susceptible of any modifications calculated to attain more consonant results.

Absence of increased secretion of intestinal fluid.

In doing so, one of the most striking differences, which at once presented itself to observation, one, too, in regard to which there could be no debate, was the almost total absence of any increased secretion of fluid from the mucous membrane, however profoundly the later might have been otherwise affected.

Choice of means of inducing this increased secretion.

We had then to consider by what means we might best promote such an increased secretion, so that by combining its employment with the experiments as previously performed, we might, at all events, assimilate the conditions in the two instances a little more closely to one another. The secretion of fluid might of course have been promoted by the use of drugs or other media introduced into the system, but the complexity of the subject would have been greatly increased by such a mode of procedure, and we therefore decided in the first place to attempt to attain the desired end by means of direct operative interference. It next became necessary to determine in what that interference should consist, and that having been settled, to test with care the effects arising from its influence, when employed alone, before proceeding to combine it with any other experiment.

Section of nerves selected.

The best means available and which appeared to warrant a hope of success was section of the intestinal nerves. Moreau's celebrated experiment on section of these nerves showed that the resultant paralysis was accompanied by a copious secretion of watery fluid from the mucous membrane, and it was previously asserted by Pflüger and Nasse that the splanchnic nerves exerted an inhibitory action on the movements of the small intestine, so that there were fair grounds for the selection of such operations with a view to their combination with the experiments on the injection of organic fluids into the circulation.

A.—Section of the Splanchnic Nerves.

Section of the splanchnic nerves tried first.

Before proceeding to repeat Moreau's experiment, the effects of division of the splanchnic nerves were carefully tested, seeing that it was desirable, if possible, to obtain a means of influencing the whole of the small intestine simultaneously, and not a mere isolated loop or loops as in the procedure adopted by Moreau. The difficulties of such an operation are considerable, and cannot be overcome without some practice, for the situation of the nerves is such that injury to important vessels and viscera is very easily caused, and the abdominal portion of the nerves in the dog is so short as to render it at first a matter of difficulty to distinguish and isolate such small cords as they are. In our experiments the greater splanchnics alone were divided as the lesser nerves are very difficult to secure, due to their small size and to the fact that there is no such definite guide to their position as in the case of the larger nerves. This guide is afforded by the supra-renal capsule. If the outer edge of this body be carefully cleaned, the greater splanchnic may be found with comparative ease, just as it passes beneath it to enter the semilunar ganglion. The main difficulty in the way is a vein of considerable size, which, near the gland, lies close to and almost parallel with the nerve, and which is very liable to be injured in an operation performed in such a narrow space, and affording so many obstructions to the free access of light, as is the angle between the ribs, the diaphragm, and the transverse processes of the vertebræ. Numerous failures first occurred, but eight operations were successfully performed with the results shown in the following Statement:—

Difficulties of the operation.

Eight operations successfully performed.

No.	Nerves divided.	Periods of survival after operation.	RESULTS.
1	Right ...	A few minutes ...	No result.
2	Left ...	1 hour ...	Mucous membrane dry.
3	Left ...	1 „ ...	„ „ pale and dry.
4	Left ...	1 „ ...	„ „ „ ,
5	Both ...	½ „ ...	„ „ „ ,
6	Left ...	1 „ ...	„ „ „ „
7	Right ...	9½ „ ...	„ „ „ „
8	Both ...	10 „ ...	„ „ dry.

The following cases have been selected from among these experiments as being the most interesting of them:—

Selected cases of the operation.

EXPERIMENT I. *(No. 5).*—A healthy young pariah dog was put under the influence of chloroform, and both splanchnic nerves were divided. The administration of chloroform was then continued for half an hour longer, and the animal subsequently killed. The mucous membrane of the small intestines was not in the least congested; it was on the contrary pale and dry-looking, and the cavity of the gut was absolutely devoid of any fluid whatever.

Both nerves divided without result.

EXPERIMENT II. (*No.* 7).—A large healthy pariah dog having been put under the influence of chloroform, the right splanchnic nerve was divided. The animal was killed 9½ hours after the operation and a *post-mortem* examination performed at once. The external surface of the intestines was somewhat congested, and there was a little absolute peritonitis in the neighbourhood of the wound, but there was hardly any fluid in the abdominal cavity. Although no evacuations had been passed subsequent to the operation, the intestines were found to be empty, and their mucous surface pale and dry. The bladder was full of urine, secreted since the operation. This was carefully examined and was found to contain a trace of albumen, but no evidence of the presence of sugar could be detected in it.

Right nerve divided; no result; no glycosuria.

EXPERIMENT III. (*No.* 8).—A healthy pariah dog of average size was put under the influence of chloroform, and both greater splanchnic nerves were divided. Ten hours afterwards chloroform was again administered, and the administration continued until death occurred. An immediate *post-mortem* examination was performed, the abdomen being opened before circulation had ceased. The intestines were pale externally, and the mesentery only here and there showed any evidences of peritonitic action. The intestines were empty, and the mucous membrane dry; in greater part normal in appearance, but here and there coated with a thin layer of sanguineous exudation.

Both nerves divided without result.

In all cases careful dissections were made, in order to ascertain without doubt that no mistake existed in regard to the actual division of the nerves. In not a single instance was there the slightest evidence of any increase in the secretion of intestinal fluid; on the contrary the mucous membrane in the majority of cases was pale and somewhat dry in aspect. In no instance was there any affection of the membrane beyond mere small patches of congestion, or of a thin layer of sanguineous exudation, but not more marked than may frequently be observed in *post-mortem* examinations of healthy animals which have died under the influence of chloroform without having been subjected to any operation, and which, if they were in any degree due to the operations in question, were fairly ascribable to the irritation and tendency to inflammation induced by the opening of the abdominal cavity and the handling of its contents.

No increased secretion caused by section of the nerves in any case.

Increased activity in the intestinal contractions was in no case observed; but as this was not the subject of immediate enquiry, and as the openings in the abdominal parietes were closed as rapidly as possible on the completion of the operation, it may well have occurred and yet have escaped notice.

Nor any increased activity in the intestinal movements.

B.—Section of the Mesenteric Nerves.

These experiments having failed to achieve the end in view, it was still necessary to repeat Moreau's experiment exactly, as the possibility remained of the semilunar ganglia and solar plexus acting as an independent nervous centre in regulating the secretion of the mucous membrane.

Moreau's experiment repeated.

The operation in this case, although in some respects apparently much simpler and more easy of performance than that of section of the splanchnic nerves, is yet beset with difficulties peculiar to itself, and which render great care in its performance necessary. The nerves, as is well known, lie close to the vessels, and are of such small size as to render careful dissection necessary in order to secure their thorough division, and it is in this dissection that the difficulty of the operation lies; for, if the vein be much disturbed, or in any way roughly handled, coagulation of its contents occurs at the isolated portion, and is followed by extreme congestion of the mucous membrane and mesentery, with extravasation between the layers of the latter, and effusion of blood into the cavity of the gut to such an extent as to deprive the observation of all value in regard to the point immediately at issue. Cases of this kind will be given in detail farther on, and the matter is mentioned here only with the view of pointing out that the operation is by no means so simple and easy of performance as might be supposed. The circulation in the portion of gut under operation not unfrequently ceases for a time owing to another cause—the arterial coats when irritated often contract to such a degree as to occlude the canal of the vessel. This impediment to the circulation is however of no moment as the irritated coats soon relax, and the current of the blood is rapidly restored.

Difficulties of the operation.

Sixteen experiments of this kind were performed, the results of which are shown in the following Statement:—

Sixteen experiments performed.

No.	Nature of operation.	Periods of survival after operation.	Results.
1	Moreau's operation ...	1 hour ...	No result.
2	Ditto ditto ...	" ...	Ditto.
3	Ditto ditto ...	" ...	Ditto.
4	Moreau's operation combined with injection of organic fluid into the veins.	3 " ...	Ditto.
5	Moreau's operation ...	1 " ...	Ditto.
6	Moreau's operation—2 loops	9½ " ...	Ditto.
7	Moreau's operation with injection of salt and water into the loop. ...	8½ " ...	Fluid absorbed; loop empty.
8	Moreau's operation ...	1 " ...	Vein plugged. Deep congestion.
9	Ditto ditto ...	9½ " ...	Loop distended with blood, and vein occluded.
10	Ditto ditto ...		
11	Ditto ditto ...	10 " ...	Ditto ditto ditto.
12	Moreau's operation—2 loops.	7¼ " ...	General peritonitis. Loop containing a little strawberry-juice fluid.
	a.—Injected with water.	9 " ...	*a.*—Fluid absorbed—empty.
	b.—Not injected. ..		*b.*—Distended with clear serous fluid.
13	Moreau's operation—3 loops		One loop distended with blood, its vein occluded. Other loops empty.
14	Ditto ditto—2 loops.	10 " ...	
	a.—Injected with water.	9¼ " ...	Both loops empty.
	b.—Not injected. ...		
15	Moreau's operation ...	9¾ " ...	Contained fluid.
16	Ditto ditto ...	8 " ...	Empty. Mucous membrane dry.

Before proceeding to give a more detailed account of some of the more remarkable of these cases, and more especially of those exceptional ones in which effusion of fluid really did occur, it may be well to point out a few general facts regarding the entire series. It is remarkable that the animals subjected to operation in no single instance showed any distinct evidences of suffering during the period in which they were allowed to survive the operation. We were naturally averse to keep them alive longer than necessary, and at first only kept them for an hour or two, continuing the administration of chloroform throughout. When, however, such experiments were found only to produce negative results, we were necessarily constrained to prolong life for some time, lest these might have been due to the shortness of the interval elapsing between the operation and death.

General observations regarding this series of experiments.

Very little peritonitic action was set up in the majority of instances, and in those in which peritonitis did occur to any extent, it was usually ascribable to an extra amount of handling or injury of the viscera incident on some accident in the course of operation, as, for example, on hæmorrhage from the vessels occurring during the separation of the nerves, or on the plugging of the vein with coagulum, and the resultant extreme congestion of the gut and fold of mesentery supplied by it. When general peritonitis had occurred to any extent the mucous membrane of the gut presented patches of mucus of a prune-juice colour such as is ordinarily present in such cases, but these were not localised to the loop, the nerves of which had been divided, nor was there any effusion of fluid into the gut.

Little peritonitis in most cases.

The following cases have been selected as affording illustrations of the various phenomena observed as results of the operation:—

Illustrative cases.

EXPERIMENT IV (*No.* 6).—A healthy young pariah dog was put under the influence of choloroform, and an incision having been made along the middle line of the abdomen, the cavity was opened and a loop of the small intestine drawn out. The vessels supplying the central portion of this loop were then carefully cleaned, and every thing resembling a nervous filament divided. Ligatures were then applied round the intestine at the terminal twigs of the vessels, the accompanying nerves of which had been divided, and finally a loop of intestine on either side was ligatured. The three ligatured loops were now returned to the abdomen, and another portion of the small intestine having been taken out was treated in exactly the same way. The second set of ligatured loops was next returned to the abdomen, and the wound in the parietes carefully stitched up.

Operation described.

The dog rapidly recovered from the influence of the chloroform, showed no indications of pain, and, 9½ hours after the operation, appeared to be quite cheerful in spite of having six loops of its intestines firmly ligatured, two of which, moreover, had their nervous supply divided.

Chloroform was again administered, and continued until death occurred. The abdomen was opened before circulation had ceased, and was found to contain about an ounce of serous fluid, but there were no evidences of general peritonitis. The ligatured loops of intestine were next laid open, but were found in no way to vary from one another, whether

1st case: no result.

their nervous supply had been divided or not. They were all empty, and of a reddish brown appearance internally, due to sanguineous staining of the normal mucus. This staining extended uninterruptedly from the highest ligatured loop to a little beyond the cœcal extremity of the lowest one. Above the upper ligature, the mucous membrane of the gut was pale and somewhat more moist than in the ligatured loops.

Experiment V (*No.* 8).—A strong healthy pariah dog was put under the influence of chloroform, and three loops of intestine were ligatured as in the preceding experiment, the nerves of the central loop being as before divided whilst those of the lateral loops were left intact. The intestine was then returned to the abdomen and the wound sewed up.

2nd case: occlusion of the vein: extreme congestion.

After the lapse of an hour the abdomen was again opened, and the ligatured loops were examined. The vein of the central loop had become occluded with coagulum, which had caused extreme congestion of the corresponding portion of the gut, but beyond this congestion no other difference existed between the central and the two lateral loops.

Experiment VI (*No.* 9).—A large healthy pariah dog was put under the influence of chloroform, and the division of the nerves of a loop of intestine performed in the usual manner.

3rd case: occlusion of the vein: sanguineous effusion.

Nine hours and a half subsequently the animal was killed with chloroform, and the abdomen opened. The ligatured loop, the nerves of which had been divided, was distended like a sausage, and of an intense black colour. There was extreme extravasation along the lines of the vessels in the corresponding portion of mesentery, and the layers of the latter close to the intestine were widely separated by a wedge-shaped mass of tarry blood. The cavity of the gut was distended with black blood, and the tissues of its walls were infiltrated and thickened with similar fluid. This extreme congestion and extravasation had been caused by the complete occlusion of the vein by coagulum at the site of the section of the nerves.

Experiment VII (*No.* 16).—A small pariah dog was put under the influence of chloroform, and the operation of section of the nerves of a loop of the small intestine performed in the usual way.

After an interval of eight hours, chloroform was again administered until death ensued, and an immediate *post-mortem* examination was then performed.

4th case: no result.

There was no peritonitis. Not the slightest difference could be detected between the central ligatured loop of intestine in which the nerves had been divided, and the two lateral ones in which they remained intact. The mucous surface was exceptionally dry.

A careful dissection was subsequently made of the portion of mesentery, including the divided nerves, and the division was found to have been almost, if not absolutely complete.

EXPERIMENT VIII (*No.* 14).—A healthy pariah dog was put under the influence of chloroform, and the nerves of two loops of the small intestine were thoroughly divided. Into one loop (*a*), an ounce of tepid water was then injected, whilst the other loop (*b*) was left empty.

5th case: absorption in one loop; non-secretion in the other.

Nine hours and a quarter subsequently the animal was killed, and the intestines were examined at once. The interior of the first loop (*a*) was empty, the mucous membrane being moist and covered with a layer of soft mucus of a sanguineous hue. The interior of the second loop (*b*) was also empty, but the mucous membrane was in this case dry and much less congested than that of the portions of intestine on either side of the ligatures.

The congested state of the mucous membrane was probably due to the fact that a considerable amount of peritonitis had been caused by the operation.

EXPERIMENT IX (*No.* 12).—A large healthy pariah dog was put under the influence of chloroform, and the two nerves of loops of the small intestine were divided in the usual way. Into one loop (*a*) an ounce of water was injected, whilst the other (*b*) was left empty.

Nine hours afterwards the animal was killed, and a *post-mortem* examination was performed at once.

6th case: absorption in one loop; secretion of fluid in the other.

The former loop of intestine (*a*) was empty, and contained merely a little sanguineous mucus, but the latter (*b*) was fully distended with clear serous fluid, containing a few small pale yellowish flocculi. The mucous membrane was soft and of a macerated aspect.

No mistake could have been made as to the identity of the two loops, as they had been carefully distinguished by means of different ligatures, both ends being cut short in one case, whilst one end was left uncut in the other. The flocculi contained in the serous fluid were examined microscopically, and were found to consist of a molecular basis crowded with bioplasts of all sizes, and exactly resembling the flocculi occurring in choleraic dejecta.

Careful dissections of the nerves were made in both cases. In neither were they entirely divided, but the remaining nervous connections were decidedly greater in the second loop (*b*) than in the first (*a*).

Experiment X (*No.* 15).—A large healthy pariah dog was put under the influence of chloroform, and the nerves of a loop of intestine were divided in the usual way. The animal was killed 9¾ hours afterwards, and a *post-mortem* examination was performed at once.

7th case: secretion of fluid.

The central loop of intestine contained brownish fluid. The mucous membrane of the two lateral loops was very dry, and was coated with a layer of brownish material identical in colour, and probably in nature, with that dissolved in the fluid in the central loop, of which the nerves had been divided. A careful dissection was made of the nerves, and it appeared that, whilst the main trunks had been freely divided, one or two lateral connecting loops of some size remained intact.

Nervous influences regulating intestinal secretion analogous to those regulating secretion of sub-maxillary gland.

The two last cases are peculiarly instructive and noteworthy, inasmuch as they appear to demonstrate a fact which had never previously been experimentally determined, namely, that the relation which the secretion of the small intestines bears to their nervous supply is strictly analogous to that which has long been known to hold in regard to the secretion of the submaxillary gland and its nervous supply. It was an ascertained fact that partial paralysis of that gland induced hyper-secretion, whilst total paralysis diminished the secretion, but, in as far as we can ascertain, it was a matter of mere conjectural probability that the same held in regard to the small intestines also. The importance of the determination of this point in reference to the pathology of cholera is very great, as it appears to indicate partial paralysis of the intestines as one of the most important lesions in the disease. What the nature of the nervous filaments, which respectively inhibit and promote the intestinal secretion, is, remains undetermined, and is a problem, the solution of which necessarily involves many difficulties, but it is, at all events, a step in the right direction to ascertain that filaments with these different functions actually do exist.

There is another point in connection with the pathology of cholera on which some additional light appears to have been thrown by the above investigations. The increased secretion of intestinal fluid in the disease has been ascribed by some to mechanical obstruction to the current of the capillary circulation, but our experiments appear to indicate that mere obstruction to the circulation causes sanguineous effusion and not hyper-secretion.

Mechanical obstructions of circulation cause sanguineous effusion.

Time has not as yet sufficed to allow of any extended series of experiments regarding the effect of division of the nerves combined with injections of organic fluids into the circulation, but we trust that the time expended in following out the above preliminary enquiries may not be deemed to have been wasted, seeing that the latter have afforded some additional information in regard to the action of the cause inducing that series of phenomena which in the aggregate constitute cholera.

We cannot conclude this Report without expressing our own sense of the imperfections under which it labours. Both in the planning and execution of the experiments we are well aware that there are no small defects, but we trust that in any estimate which may be formed of them, the very many difficulties incidental to such work in India may not be left altogether out of sight.

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A

REPORT

OF

MICROSCOPICAL & PHYSIOLOGICAL RESEARCHES

INTO THE

NATURE OF THE AGENT OR AGENTS PRODUCING

CHOLERA.

BY

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(ON SPECIAL DUTY)

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